REEF MONITORING
STETSON BANK

Objective: Identify techniques for recognizing changes over time in a natural setting.

Materials:

- *Find the Differences* Pictures, 1 per student
- Photo series from Repetitive Photo Stations at Stetson Bank, 1 series per group
- Paper and pencil, 1 set per group

Background:

Long-term monitoring data has been collected at East and West Flower Garden Banks on a continuous basis since 1978. This was originally prompted by drilling activity in the vicinity. The Minerals Management Service (MMS, now known as the Bureau of Offshore Energy Management or BOEM), charged with regulating oil and gas production activities in the Gulf of Mexico, wanted to establish a means of determining what impacts, if any, oil and gas activities were having on nearby coral reefs. In 1993, a similar monitoring program was established by the Gulf Reef Environmental Action Team (GREAT) at Stetson Bank.

Together, these long-term monitoring activities constitute one of the longest term monitoring programs of a coral reef anywhere in the world. They actually predate the formation of Flower Garden Banks National Marine Sanctuary (FGBNMS) in 1992 and the addition of Stetson Bank to the sanctuary in 1996.

Over the years, these monitoring activities have changed only slightly in number and scope. Today these monitoring activities include the following:

East and West Flower Garden Banks:

- 40 repetitive photo stations – analyzed for growth, loss of tissue, coral cover and incidents of bleaching and disease
- 60 repetitive close-up stations – examine the advance or retreat of colonies of *Diploria strigosa* (a species of brain coral)
- 14 10-meter transects – analyzed for percent cover, species diversity, frequency of occurrence and dominance
- Video transects – show general conditions of the coral communities along the perimeters of the study sites

Stetson Bank:

- 49 repetitive photo stations – analyzed for changes in coral and sponge cover

Repetitive photo stations are the biggest part of these monitoring programs. The purpose of these stations is to capture the same photo at the same place every year, for comparison.

Photo: FGBNMS/Bernhardt

Initially, 75 photostations were established. However, over time, some of these stations have been lost.

Stations are marked by metal pins embedded in the reef, with number tags attached. This seems to be the best way to establish a permanent marker with little impact to the reef itself.

To make the photos the same every year, researchers developed a special T-frame on which to mount the camera. As its name suggests, this metal frame is shaped like the letter 'T'. The camera is mounted in the middle of the crossbar at the top of the 'T' with the lens facing down toward the ground. A compass and camera flashes are also mounted on the crossbar.

Photo: Joyce & Frank Burek

When taking photos, researchers use the same T-frame, camera and compass year after year to make sure they get the same results. The base of the T-frame is placed at the pin location. The frame is rotated until it is facing north, then a picture is taken. This system keeps the camera the same distance from the seafloor and allows the camera to capture the exact same area in the image every year.

Monitoring Procedures

Since each diver participating in the research effort has a limited amount of time he or she can stay underwater, work is conducted in shifts. Each dive team has a specific task to accomplish so that the next shifts will be able to make the most of their bottom time (time underwater). For more details on this, please visit http://flowergarden.noaa.gov/science/stetsonmonitor.html.

Monitoring Challenges

Of course, no system is perfect! When this system was first established we didn't have digital cameras so film cameras were used. This means that the researchers were unable to tell if their images were captured correctly until they surfaced, returned to shore, and had their film developed. Then, if any of the pictures did not turn out, the researchers would have to return to the site and take all of the photos again.

Once digital cameras were available and affordable, there was concern that the focal length of a new camera would result in photos capturing a different size area. So, it was decided to continue with the existing film camera set up until further notice.

Unfortunately, in 2007, there was some kind of equipment failure with the camera during both East and West Bank and Stetson Bank monitoring trips resulting in no usable photos. Both trips had to be rescheduled and all stations re-photographed. On the return trips, the film camera was used again, but researchers also experimented with a digital camera as a replacement.

In 2008, sanctuary researchers were able to arrive at a combination of camera, lens and T-frame height that would closely match photos from previous years. As a result, all Stetson monitoring 2008 photos were taken with a digital camera system.

So, what other challenges are associated with this type of monitoring project? As with any project at sea, weather and sea conditions are always a concern. Researchers schedule the monitoring to take place in the same month each year, but that doesn't always mean that is when it will happen. Mother Nature may have other ideas. Rescheduling the trips is also a challenge because they depend on availability of both staff time and a research vessel to get them there. Once on site, equipment failure and lighting conditions may affect the quality of the photos themselves.

The job of the researchers is to manage time and materials so they are as prepared as possible when the next monitoring opportunity presents itself.

Preparation:

A. Collect "Find the Differences" cartoons. These are often available in the Sunday comics of your local newspaper. You can also find books of images that challenge people to spot the differences.
B. Laminate "Find the Differences" pictures so that they can be used over and over again.
C. Print and laminate full-color sets of the Stetson Monitoring photos available on the web site at http://flowergarden.noaa.gov/document_library/eddocuments.html. There are photo series from 3 different photo stations, but you may need to make more than one copy of each series so that each of your student groups will have a set to examine.

Note: Depending on the age level of your students, we suggest you use the following selection of photos from each series: Elementary—every 3rd photo; Middle School—every other photo; High School—all photos.

Procedures:

ENGAGE

1. Divide the class into groups of 3-4 students and assign each group a work area.
2. Distribute one "Find the Differences" picture to each student.
3. Challenge each student to find as many differences as possible in his/her picture within a 2-minute time frame.
4. Have students within each group swap pictures and try to find the differences again. Allow another 2 minutes.
5. Repeat the picture swap until each student has seen all of the pictures within his/her group.

EXPLAIN

1. Within each group have the students discuss on average how many differences they were able to find in each of the "Find the Differences" picture sets and how they found those differences. What techniques did they use? In which pictures were the differences harder or easier to find? Did color make it easier or harder? Did the subject matter make it easier or harder? Did it matter how "busy" the picture was?
2. Have each group select one person to report the group's findings.
3. Engage the entire classroom in the same discussion so that each group can share its findings. Make note on the board of the different techniques used to find the differences. The list may include some or all of the following: use prior knowledge (previous experience with these types of puzzles), examine small sections of the picture at a time, overlay the picture with a grid, write down the changes as they are found, repeated sampling, cover part of the picture.

EXPLORE

1. Distribute one series of photo station photos to each group.
2. Explain that these photos were taken at Stetson Bank, part of the Flower Garden Banks National Marine Sanctuary, in the Gulf of Mexico. The photo stations were located 60-80 feet underwater.
3. Challenge each group to identify and document the changes that have taken place from year to year within their set of photos. Allow 5-10 minutes for this process.
4. Collect the photo sets and redistribute them to the groups so that each group has a different photo station than before.
5. Challenge each group to again identify and document the changes that have taken place from year to year within their set of photos. Allow another 5-10 minutes for this process.
6. Repeat the photo swap until each group has seen photos from each of the three photo stations.

EXPLAIN

1. Within each group have the students discuss on average how many differences they found at each of the photo stations and how they found those differences. How did this compare to the "Find the Difference" activity? Was it easier or harder? Why? Did they use the same techniques in both activities? Was one photo station easier or harder than another to evaluate? Was lack of familiarity with the subject an issue?
2. Have each group select one person to report the group's findings.
3. Engage the entire classroom in a discussion of the types of changes observed from one year to the next in the photo station sets. Note on the board the different responses. These responses may include some or all of the following: color change, change in size of the objects, new objects, missing objects.

EXTEND

1. In groups, or individually, challenge students to identify the different objects in the photo station photos. Some of the objects they should be able to identify are sponges, fire coral, brain coral, algae, fish.
2. Next, direct the students to learn about the conditions for growth required of each of the biological specimens in the photos.
3. Which of these objects is likely to be an indicator of change over time? Why? *Sponges, corals and rocks are more stable objects and likely to be better indicators.* Which is not? Why? *Fish change location constantly and are therefore not an indicator of specific changes in the substrate, however they may be more likely to hang out in an area based upon what is or is not there. The amount of algae growth may indicate change, but algae is also easily removed from an area by animals, physical impacts, etc. so there would have to be substantial change from one year to the next to indicate any type of long term alteration.*
4. In groups, have students re-evaluate their original set of photo station photos. Does being able to identify the objects in the photos make it any easier to identify changes?

EVALUATE

Have each group answer the following questions regarding their original set of photo station photos.

1. Between what years were the most significant changes noted? *June 2005 to June 2006*
2. What was the nature of these changes? *Objects missing, broken, or greatly reduced in size. Lots of algae growth.*
3. What could have caused these changes? Students should do some research to find out what was happening in the Gulf of Mexico during that time. Use the following hints if needed – HINTS: What major events occurred in the Gulf of Mexico in late summer of 2005? What major event occurred on coral reefs around the world in the summer of 2005? *Hurricanes Katrina and Rita passed through the Gulf of Mexico en route to Louisiana and Texas in August and September 2005. Hurricane Katrina*

4. *passed well to the east of the sanctuary but Hurricane Rita passed directly over the sanctuary as a category 5 hurricane. In 2005 there was also a massive bleaching event on coral reefs throughout the world brought on by high ocean temperatures. Much of the fire coral at the Flower Garden Banks National Marine Sanctuary died as a result.*
5. Why do researchers create so many photo stations in an area? *Environmental monitoring doesn't look at just one spot.*
6. How does monitoring of individual stations help scientists understand the whole habitat? *Information from many small areas can be pieced together to create a bigger picture. As with any experiment, the more data points you have, the more valid the trends that are identified.*

Conclusion: Environmental monitoring is a challenging activity, especially underwater. Appropriate equipment must be selected to record the best possible results in the most consistent manner. It is also important that the monitoring procedures themselves create as little impact on the environment as possible.

Repetitive photo stations provide snapshots of growth and change at specific points in a habitat. By combining the observations at these stations, scientists can draw conclusions about the health of and trends within the entire habitat.

Web References:

Monitoring at the FGBNMS: http://flowergarden.noaa.gov/science/monitor.html

Monitoring Reports from PBS&J (2002-2003):
http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3880.pdf
and
http://www.gomr.mms.gov/PI/PDFImages/ESPIS/3/3879.pdf

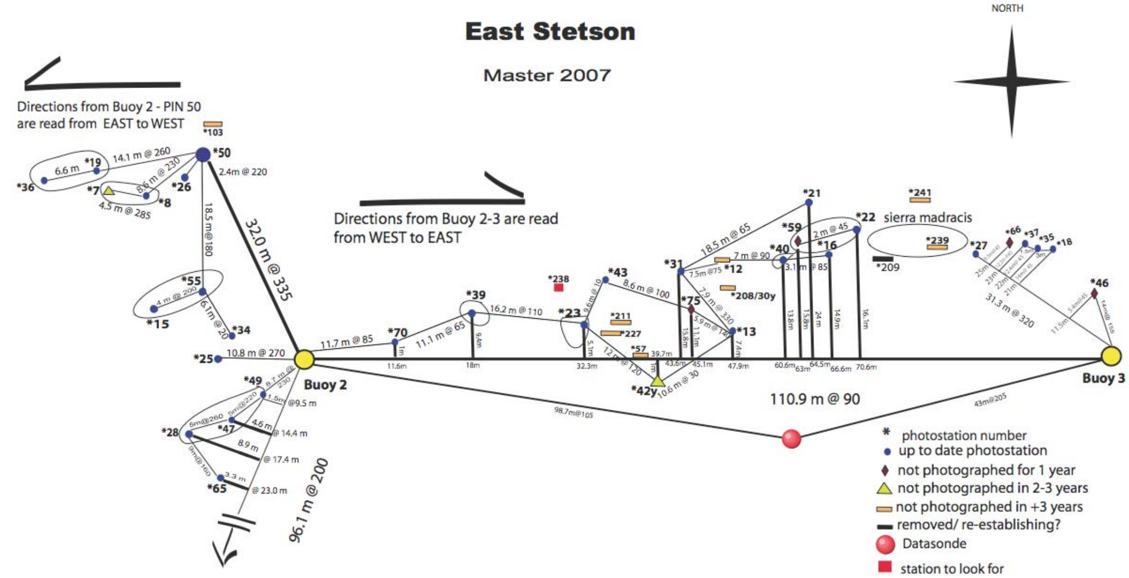
Monitoring Report from MMS (2004):
http://www.gomr.mms.gov/homepg/regulate/environ/ongoing_studies/gm/GM-04-06.html

Hurricane Rita Report:
http://flowergarden.noaa.gov/science/monitor.html (bottom of page)

Hurricane Ike Report:
http://flowergarden.noaa.gov/science/ike2008.html

Post-Hurricane Assessment from MMS (2006-2008):
http://www.gomr.mms.gov/homepg/regulate/environ/ongoing_studies/gm/GM-06-x11.html

Photo Station Reference Map:



This map helps the divers locate photo stations pins by giving them directional references from known points.

NATIONAL SCIENCE EDUCATION STANDARDS:

All Grades

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard E: Science and Technology

- Abilities of technological design
- Understanding about science and technology

Content Standard G: History and Nature of Science

- Science as a human endeavor

Grades K-4

Content Standard C: Life Science

- Organisms and environments

Content Standard F: Science in Personal and Social Perspectives

- Changes in environments

Grades 5-8

Content Standard C: Life Science

- Structure and function in living systems
- Populations and ecosystems

Content Standard F: Science in Personal and Social Perspectives

- Natural hazards
- Science and technology in society

Content Standard G: History and Nature of Science

- Nature of science

Grades 9-12

Content Standard C: Life Science

- Interdependence of organisms

Content Standard G: History and Nature of Science

- Nature of scientific knowledge

OCEAN LITERACY PRINCIPLES

5. The ocean supports a great diversity of life and ecosystems.
(c) Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
(d) Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.
(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.

7. The ocean is largely unexplored.
(b) Understanding the ocean is more than a matter of curiosity. Exploration, inquiry, and study are required to better understand ocean systems and processes.

CLIMATE LITERACY PRINCIPLES

3. Life on Earth depends on, is shaped by, and affects climate.
(a) Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight. Organisms exposed to climate conditions outside their normal range must adapt or migrate, or they will perish.

TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS)

Grade 3
(2d) Analyze and interpret patterns in data to construct reasonable explanations based on evidence from investigations.
(9a) Observe and describe the physical characteristics of environments and how they support populations and communities within an ecosystem.

Grade 4
(2d) Analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.
(2f) Communicate valid oral and written results supported by data.

Grade 5
(2d) Analyze and interpret information to construct reasonable explanations from direct (observable) and indirect (inferred) evidence.
(9a) Observe the way organisms live and survive in their ecosystem by interacting with the living and non-living elements.

Grade 6
(2e) Analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.

Grade 7
(2e) Analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.
(8a) Predict and describe how different types of catastrophic events impact ecosystems such as hurricanes.

Grade 8
(2e) Analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.
(11b) Investigate how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic factors such as quantity of light, water, range of temperatures, or soil composition.

Aquatic Science
(3a) In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.
(5a) Evaluate data over a period of time from an established aquatic environment documenting seasonal changes and the behavior of organisms.
(6b) Examine the interrelationships between aquatic systems and climate and weather, including El Niño and La Niña, currents, and hurricanes.

Biology
(2g) Analyze, evaluate, make inferences, and predict trends from data.
(3a) In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.
(11b) Investigate and analyze how organisms, populations, and communities respond to external factors.
(12f) Describe how environmental change can impact ecosystem stability.

Environmental Systems
(3a) In all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.
(8a) Analyze and describe the effects on areas impacted by natural events such as hurricanes.