Marine Biology Lesson on Understanding the Dynamics of the Reef Ecosystem

Course: Marine Biology (elective with a prerequisite in Biology required)
Grades: 11 and 12 combined
Instructor: Tanya Manternach
Expected Time: 1 week, but may be extended.

National Science Content Standards Implemented in this lesson:

A. As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry. This involves students formulating a testable hypothesis guided by the logical implementation of scientific concepts; measurement procedures and protocols; data analysis; visual representation of data, and communicate the scientific explanation developed from the experimental findings.

C. As a result of their activities in grades 9-12, all students should develop understanding of life science. This involves the students' understanding of the behavior of organisms, as well as, matter, energy, and organization in living systems.

Abstract: I will train the students in identifying the different species of coral and the protocols used to measure the health of the reef. Then I will have the students use the protocols to determine the health of two artificial reefs constructed from clay. I will have the students analyze their data to determine which reef is being stressed and develop a hypothesis to determine what environmental stresses are impacting the reef. Finally, the students will do an internet search of scientific investigations related to their hypothesis and present their findings to the class. Once all of the groups have presented, we will have a class discussion of the various ecological factors that influence the health of a reef.

Goal: To teach students how to utilize scientific protocols used in the field to test the health of an artificial reef and hypothesize the stresses affecting the reef's ecosystem in order to learn the dynamics of the ecosystem as a whole.

Objectives:

- Students will practice identifying different types of corals and other marine life.
- Students will understand the interdependence of life on the reef and the behaviors of marine organisms within the reef ecosystem.
- Students will perform scientific procedures and protocols to measure a mock reef's biodiversity and population densities over time.
- Students will be able to map corals.
- Students will be able to identify bleaching.
- Students will utilizes their knowledge of biological concepts to develop a hypothesis to investigate the potential cause of the reef ecosystem's decline.
- Students will utilize higher-order thinking skills to construct a mock reef that demonstrates an ecological change.
- Students will analyze, graph, and communicate their findings to the class.
- Students will obtain baseline data from an actual marine ecosystem that can be measured on an annual basis.

Prerequisite Knowledge:

- Students will already have had a course in biology and a marine biology unit on the marine food chain and ecological relationships.
- Students should have a basic understanding of the organisms belonging to the different animal phyla, as well as, their anatomy and physiology.

- Students should have a basic understanding of the chemistry, climatology, physics, and geology of the oceans and coastlines.
- You may want to plan time for students to research the factors influencing the health of coral reef ecosystems before they attempt to develop a hypothesis unless this information was already presented in class. Otherwise, you could allow time for students to use higher-order thinking skills to evaluate the needs of a healthy coral reef ecosystem and possible ways that these needs are not being met.
- Students should have a basic understanding of the scientific method, controlling an experiment, and graphing.

Materials:

- Mock reef made from clay or plaster, synthetic plants (algae and mangroves), sand, and paint. You may also choose to add synthetic marine animals. Make sure to include points of attachment for your transect line. Ideally, one reef should be considered healthy with lush, mangrove vegetation along the shore and the unhealthy reef could have resorts along its beach and a reduction in populations of organisms living on the reef, except for algae. The unhealthy reef should have less than 30% hard coral cover and minimal predator and herbivore population sizes. You may choose to make additional reefs to allow for smaller groups of students. You may save time and resources if you draw a poster of the reef.
- The unhealthy reef's water sample should be created with high levels of phosphate, nitrogen, or sediment. The water may also have temperatures deviating from 24-28 degrees Celsius, pH deviating from 8, and the salinity deviating from the 28-32 range.
- Chemical tests for phosphate and nitrogen can be purchased at a fish store or science catalog and water samples may be obtained by nearby streams.
- A secchi disk, used to measure water clarity (amount of sedimentation), of various sizes may from science catalogs or included in some water testing kits. Tubes containing a secchi disk used to measures streams would also work.
- A hydrometer, used to measure salinity, can be purchased from fish stores or science catalogs.
- Point Intercept (PI) frame constructed from a square of PCP piping and a rope grid (see Appendix D).
- A rope used to form the transect line that can be tied between two points on the reef. In a real reef ecosystem, the transect line can be 10 meters long in three different locations. You may want to scale down the size of your rope and model reef.
- Sample data tables to record and compare results can be found in the appendix C through F.

Technology: Internet access and a hot list of links related to reef ecology studies.

Procedure:

1. Students complete an environmental questionnaire (appendix A) assessing their attitudes about environmental responsibility, understanding the implications of humans on the environment, and their global impact (this can be done at the beginning of the course).
2. Students are presented with a power point, handout (appendix B), or replica specimens of different types of coral to learn to identify.
3. Students will use a Point Intercept (PI) frame (Appendix D) made of PCP pipe and rope to measure the abundance of hard corals, soft corals, sponge, algae, sand, rock/cement, and other (trash or fish) on the mock reef sample provided. The frame can be scaled down for smaller sampling areas. The PI sampling will be done on both the healthy and unhealthy reef. The data will be recorded in chart provided in Appendix C.
4. Students will construct a transect line spanning the mock reef. Students will scan the reef along the transect line and identify the hard corals along the transect line, draw the corals to scale on their data table provided in Appendix E, and estimate the percentage of bleaching. This will be done for both reefs.
5. Students will perform chemical tests on water samples provided for each of the two reefs and record their findings in the data table.
6. Students will compare their data from both the healthy and unhealthy reef ecosystems in Appendix C. The students should not be told which reef is healthy or unhealthy, but may need assistance in determining which reef is healthy from their data.

7. The class will be broken down into at least 2 groups. The students belonging to each group must discuss their findings compared to a healthy reef and use their understanding of reef ecosystems, to develop a testable hypothesis to determine what factor is responsible for the decline of the reef ecosystem's health. Unfortunately, in realistic environments there are numerous factors harming the coral reefs of the world, but true investigations should only test one experimental variable at a time and try to control the interference of all other variables. However, a separate group of students may develop a separate, testable hypotheses based on the same data.
8. Each group of students should write out their hypothesis and a way to test their variable including ways to control the experiment. They should include the rationale of scientific concepts used to develop their hypothesis (see Appendix F)
9. Then, each group should perform research to determine if any other scientists have done work testing their hypothesis and summarize the results of their findings on their form provided in Appendix F. and present what they learned to the class.

Accommodating the Lesson:

- The instructor may chose to simply construct a second data table that lists data changes over time instead of having students construct a second set of mock data samples to support or refuse another group's hypothesis.
- The instructor may want to have the whole class work together to develop and test the same hypothesis. The instructor may then chose to create his or her own mock data to refuse or support the class hypothesis.

Enriching the Lesson:

- The teacher may chose to create a fictitious graph to show how each artificial reefs' data over time and have the students analyze these graphs before developing their hypothesis.
- Since the year 2000, Marine Biology students from Hempstead High School in Dubuque, Iowa have had the opportunity to travel to a marine environment to investigate a coral reef ecosystem first hand. However, there has never been a collection of baseline data from any given site. Ideally, I would like to take a group of students to research the same coral reef site annually and create a baseline data study and have students discuss the health of this site over time and possible threats it may be facing.
- Our classroom also has a saltwater aquarium that allows students to maintain appropriate water chemistry. An aquarium with live rock and corals may be used in conjunction with the mock reef sampling.
- Another way the activity could be enriched by having the students exchanges their hypothesis with another group. Once the group receives, another groups hypothesis, they will use that group's rational to construct mock data that will either support or refuse the hypothesis. Students will need time to research and prepare the mock data and should seek council from the instructor before beginning any work. The mock data may require students to construct a second, mock reef that represents data obtained in the future or from a separate habitat. The data may take the form of differing population densities, percentages of bleaching, artificial water samples, changes in land cover surrounding the beach, or numbers indicating climate changes. Students perform tests and analyze the mock data presented from the other group to determine if their hypothesis was supported or refuted. Each group will write up and present an explanation of their experimental findings to the class.

Possible Extension Activities:

- Help the Dubuque's National River Museum and Aquarium paint "All Drains Lead to the Ocean" markers on the city' storm drains to educate the public of environmental stewardship and our global impact.
- Research endangered habitats and animals in our area and develop ways to educate other and help with conservation practices.

Assessment:

- Students will be assessed on their ability to use scientific concepts to develop a logical and testable hypothesis.

- Students will be assessed on the accuracy of their data collection, which coincides with their ability to following protocols and identify marine life.
- Students will be assessed on the accuracy of their data analyses and understanding of scientific concepts to develop a conclusion based on their findings.
- Students will self-assess their environmental attitude based on their responses to the pre and post lesson questionnaire.
- Students take a knowledge-based test of concepts in marine ecology, scientific method, data analysis, and protocols.

Interdisciplinary Connections:

- Students could develop sculptural skills while constructing an artificial reef in collaboration with an Art instructor.
- Students could develop writing and speech skills while constructing their presentation in collaboration with an English or Speech instructor.
- Students could develop skills in analyzing data and graphing in collaboration with a Math instructor.

Acknowledgments: The idea for this lesson plan and the protocols used were obtained from my experience participating in the Earthwatch Bahamian Reef Survey in July 2008 and the principal investigators John Rollino and Tom McGrath. Additional coral information was obtained, but not quoted from Reef Coral Identification by Paul Humann, published by New World Publishing Inc. 1993 Jacksonville, FL.

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Web Resources: http://www.earthwatch.org/expeditions/rollino.html and http://www.thonline.com/multimedia/?id=1520

Appendix A: Student Questionnaire

1. How often do you enjoy nature, such as hiking or going to a park, in a year?

2. What are some ways you try to help the environment, such as recycle or carpool?

3. Do you think about or care about what happens to the beaches in Texas, Coral Reefs in Florida, or anywhere else in the world? Why?

4. Do you or does your community affect the quality of those habitats? How?

5. Do you think our government should control the pollution or environmental policies of companies if it costs the consumers more money or lose jobs overseas?

6. Do you think our government should preserve sections of land?

7. Would you stop buying a product if you knew that it was environmentally damaging or was unsafe to animals, such as certain types of fish that are being over fished or tuna that is harvested at the expense of many dolphins?

8. Do you think it is acceptable to alter natural habitats for building new industry or road if it destroys endangered species' habitat?

9. If you went on vacation would you stay at an eco-friendly resort if it is not as luxurious, more expensive, or asked you to volunteer your services to help the environment or animals while you stayed at the resort?

10. Do you think it is acceptable for tourists to step on coral, litter, harvest items from the ocean or shore, or disrespect animals?

11. Do you think the government should require farmers to use farming practices that reduce their crop yield or restrict them from farming sections of their land near water ways?

12. Should our government refuse trade with all companies that do not follow strict pollution regulations?

13. What are some ways that the city of Dubuque, Iowa could implement conservation programs in our community?

14. What are some ways you could volunteer to help our environment?

15. Have you ever written a legislator to advocate policies to help the environment or animals?

Appendix B: Caribbean Hard Coral Identification Activity (Key)

**** omit answers or descriptions to use in the classroom***

Coral Matching: Use the description to match the picture of coral to the correct common name. Write the letter representing that picture in front of the description. The first one is done for you.

Image	Common Name
H.	**Star (encrusting or mountainous):** • Densely packed, uniformly distributed, cone-like raised bumps containing polyps over the surface. The surface may be lumpy. • Yellow, tan, or other pale colors. • Forms a large mound or encrust over other surfaces
G.	**Starlet Coral:** • Densely packed, uniform dimples (calyxes) containing polyps over the surface. • Yellow to gray in color • May form smaller, rounded mounds
O.	**Mustard Hill:** • Lumpy pile about a foot high. • Closely packed and evenly distributed polyps throughout • Bright yellow, greenish-yellow, or gray color. Polyps appear soft.
P.	**Grooved Brain Coral:** • Wide, wavy, and raised ridges of polyps resembling a brain. • Yellow, green, brown, or gray color • The ridges have a depressional grove running along the center of the ridge • Deep valleys in between ridges • Forms a large, circular mound
R.	**Smooth/common Brain Coral:** • Narrow and sharp ridges of polyps. • The ridges are wavy and raised above the valleys. • Forms a large, circular mound • Yellow, green, brown, or gray color
Q.	**Knobby Brain Coral:** • Wavy, raised ridges of polyps and deep valleys that seem to radiate from a common location. • It looks like a slab of dough dropped over the reef. Usually flat, encrusting • Yellow, green, brown, or gray color

A.

Image courtesy of R. Hays Cummins 2007.
http://jrscience.wcp.muohio.edu/html/tropecoimages.html

B.

Image courtesy of patricklynch.net 2008.

C.
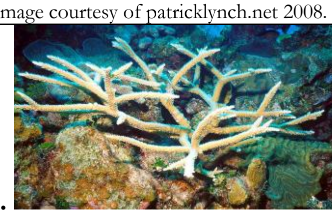
Image courtesy of www.reefnews.com 2002.

D.


Image courtesy of Matthew Wells 2006.

E.

Image courtesy of www.istockphoto.com 2008.

F.

Image courtesy of R. Hays Cummins 2007.
http://jrscience.wcp.muohio.edu/html/tropecoimages.html

I.	**Elliptical Star Coral** • Polyps arranged in densely packed, raised ellipses almost an inch in size. • The ellipses are uniform throughout and are not on stalks, but are embedded in the coral mass. • The entire mass grows as a hemisphere about a foot in size. • Yellow, cream, brown, or gray color.
J.	**Lettuce Coral:** • Leafy, overlapping, and folded blades of coral that may appear like wavy edged plates. Not usually taller than a foot, but covers a widening patch. • The texture has a network of veins over the surface. • Green, yellow, or gray in color.
K.	**Rose Coral:** • Wavy, striated ridges that are folded. • The ridges usually meet at a central valley and flare out on the edges. • It is a flat, oval structure. • Greenish-yellow or brown in color
L.	**Flower Coral:** • Several larger elliptical or disk shaped coral cups containing a larger polyp. • Each oval disk is raised upon a stalk. All stalks are attached at the base but are spaced out. • Yellow, brown, gray, or blue-green
M.	**Single Disk Coral:** • One disk coral that looks like a large ellipse or circle. Rough fleshy texture. There may be a rim outlining the central disk. • It may be on a short stalk. • Brown, gray, or bluish-green color.
F.	**Stubby Finger Coral** • Short, widely spaced pillars that may lie on the surface. Resemble fingers. • The thickness is wider than your thumb. Stubby and blunt ended. A few terminal "Y" branches at the tip. • May be yellow, brown, or gray, but comes in several other colors
D.	**Purple Finger** • Pale purple in color • Does not move in the water • Pillars growing upwards

G. 

Image courtesy of the Florida Marine Research Institute 2008.

H. 

Image courtesy of flickr.com 2008.

I. 

Image courtesy of Jacobson Associates & CDIslands. 2008.

J. 

Image courtesy of www.flickr.com 2008.

K. 

Image courtesy of jlyle 2004 from http://dive.scubadiving.com/members/tripreports.php?s=2735

L. 

Image courtesy of Jacobson Associates and CDIslands. 2008.

M. 

Image courtesy of John www.picasaweb.google.com 2008.

E.	**Branched or Thin Finger Coral** • Narrow, branching pillars. Less than a few feet long. May branch in a "Y" • Smooth surface, with uniform, embedded polyps. • Usually yellow, brown, or gray color • Polyps may show during the day
B.	**Staghorn Coral:** • Narrow, branched columns similar to antlers. Usually tangled. • Small, tubular bumps containing polyps cover the surface. Rough texture. Terminal polyps are white. • Yellow to Brown in color.
C.	**Elkhorn Coral:** • Looks like a rack of antlers from elk that flat and fanned out at the ends. • Small, tubular bumps containing polyps cover the surface. Rough texture. Terminal polyps are white. • Yellow to Brown in color.
A.	**Fire Coral:** • Mustard yellow to brown color. • White tips and short branches. • Smooth Surface and thick walled. • Hair-like polyps and pin sized holes. • Stings cause long lasting, painful blisters • May encrust over other surfaces or grow upwards as blades with wide terminal ends. May be wavy.
S.	**Cactus Coral** • Fleshy coral that appears as a flat, disk with raised, wavy ridges outlining the edge and maze-like throughout. Ridges may not reach the center. • The ridges are not continuous or uniform and are separated by wide valleys. Green in color with lighter colored ridges.
N.	**Golf Ball Coral** • Small, round or oval coral • Yellow to brown in color • Large, triangular depressions where the polyps are found (similar to elliptical coral, but smaller size and larger polyp calyxes). • The depressions are uniform over the entire surface

N.

Image courtesy of 2008
http://coralpedia.bio.warwick.ac.uk/en/corals/favia_fragum.html

O.

Image courtesy of flickr.com 2008.

P.

Image courtesy of Wikipedia.com 2008.

Q.

Image courtesy of Nathan Smiley USGS 2007
http://soundwaves.usgs.gov/2007/01/

R.

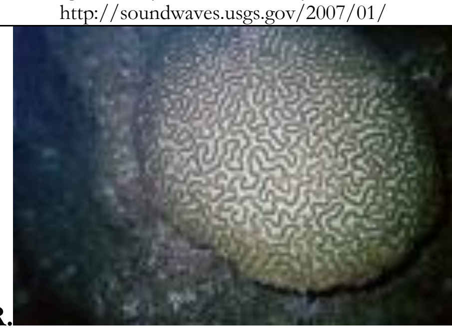

Image courtesy of Jim Simmons 2003. members.cox.net

S.

Image courtesy of 2009
http://fstop.org/trips/bonaire/coral_sponge/default.html

Appendix C: Data Collection Table (Key)

**** omit answers or descriptions to use in the classroom***

Activity/Test	Reef A	Reef B
Describe the type of land cover surrounding the reef		
Nitrogen Level		
Phosphate Level		
Clarity/Turbidity/Rigosity/Siltation		
Temperature		
pH Level		
Salinity		
Percentage of Hard Corals		
Percentage of Soft Corals		
Percentage of Algae		
Percentage of Other (rock or sand)		
Percentage of Sponge		
Percentage of Herbivores		
Percentage of top carnivorous predators		

Appendix D: Random Sampling of Point Intercept

Directions: Randomly place your PI frame on the reef. Record the type of cover found beneath each of the intercept points (where the strings cross on the frame) and record the data as tallies for each of the categories.

Hard Coral:	
Reef A:	Reef B:

Soft Coral:	
Reef A:	Reef B:

Sponge:	
Reef A:	Reef B:

Rock/Sand	
Reef A:	Reef B:

Algae:	
Reef A:	Reef B:

Top Predators:	
Reef A:	Reef B:

Herbivore:	
Reef A:	Reef B:

Appendix E: Mapping Transect Data

Directions: Draw and label by letter (found in Appendix B) the hard corals present along each side of the transect line and estimate their percentage of bleaching. Record your information in the tables below.

Reef A (each box of mapping represents 1 foot on our model)

Mapping of Hard Corals		**List the hard corals within this section of the transect.**	**What % of the coral was bleached?**
Draw all corals within 6 in. right of the transect:	*Draw all corals within 6 in. left of the transect:*		
Transect line →			
	1ft		
	2ft		
	3ft		
	4ft		
	5ft		

Reef B (each box of mapping represents 1 foot on our model)

Mapping of Hard Corals		**List the hard corals within this section of the transect.**	**What % of the coral was bleached?**
Draw all corals within 6 in. right of the transect:	*Draw all corals within 6 in. left of the transect:*		
Transect line →			
	1ft		
	2ft		
	3ft		
	4ft		
	5ft		

Appendix F: Experimental Design Questions

1. Which reef do you think is considered unhealthy at this time?

2. Why did you consider this reef unhealthy?

3. What might be some factors causing the decline of this reef?

4. Although more than one factor can influence the health of the reef, scientific investigations only test one variable (factor) at a time. All other variables must be controlled to avoid interference data. What do you hypothesize is the major threat to this reef?

5. What scientific concepts did you base your rationale for your hypothesis on?

6. Design an experiment that would test your hypothesis in a hypothetic (pretend) environment.

7. Research your hypothesis to determine if your hypothesis has been tested by others or if you can find data online. Record your findings below.

8. In conclusion, summarize what you learn about your hypothesis? Was your hypothesis supported by other scientists? Do you find support for your hypothesis or did you find evidence that refutes your hypothesis?

9. What variable could you test next?

10. Some scientists predict that nearly all reefs will be extinct in 2030. What do you think?

11. What might be some ways that we could help conserve Earth's reefs?