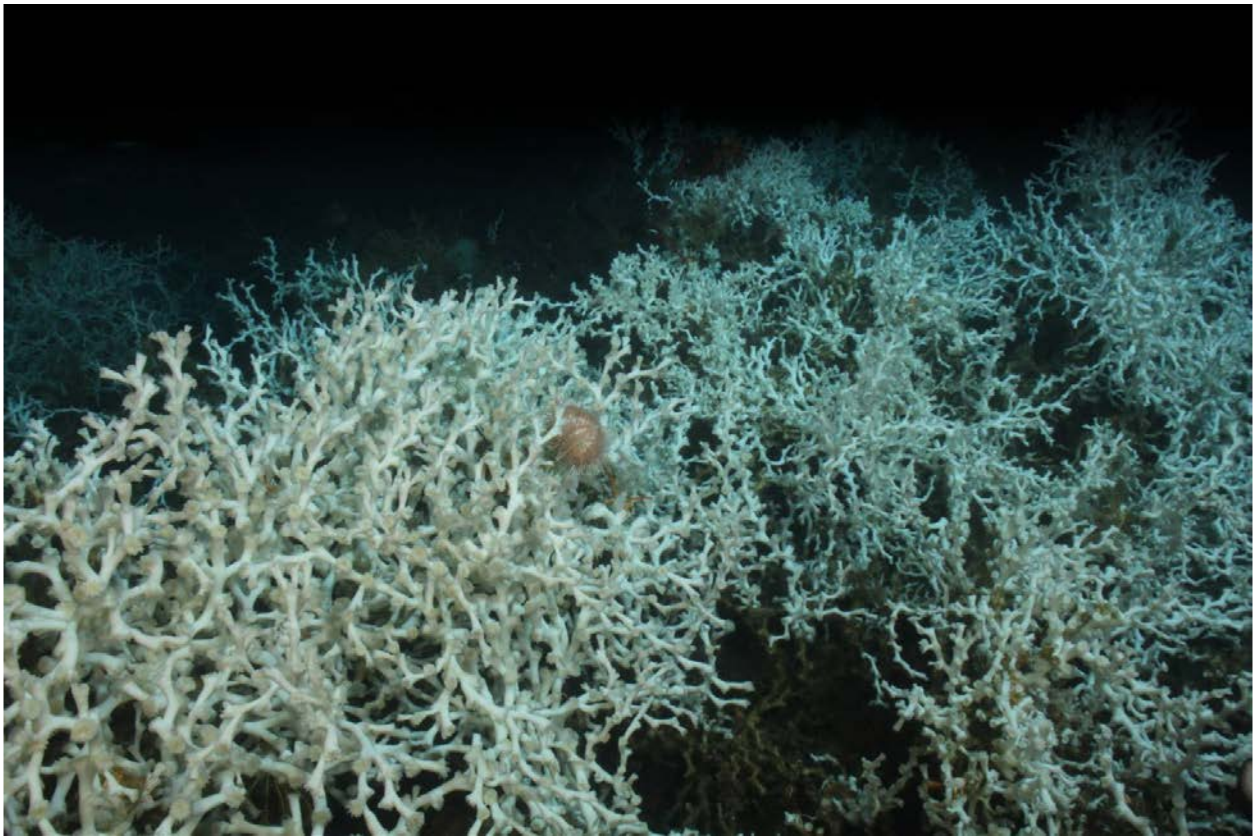


Lophelia II: Understanding Deep-Sea Coral Ecology

Student Handouts

MEMO

TO: Marine Research Science Group
FROM: Deep-water Resources Management Office, Bureau of Ocean Energy Management (BOEM)
RE: Recommendations within area *Lophelia Gardens 100 (LG100)*

Pinnacle Petroleum has expressed interest in doing exploratory drilling within the *Lophelia Gardens 100* (LG100) area of Bluewater Gulf. We need to know which areas within the LG100 section need to be off limits to any drilling activity and which of their five proposed exploratory sites could be opened to Pinnacle for drilling. Your group will need to prioritize these five sites within LG100 as to risks to corals and coral habitat from drilling (High/Medium/Low) as well as to other sensitive areas (i.e., archaeological sites) and support your claims with evidence. Please also indicate trade-offs that scientists, resource managers and representatives from Pinnacle Petroleum must consider when negotiating a permit.

In addition to information on BOEM attached to this memo, your group will receive various maps with notes describing each map. These will include 1) a map of possible hard surfaces (i.e., referred to as "amplitude"), 2) a map showing known coral occurrences, 3) a map showing seafloor topography (a.k.a. "bathymetry"), 4) a map combining potential hard surfaces and bathymetry, and 5) a map with existing wells, known shipwrecks, and other notations. Be sure to read the notes on the back of each map carefully.

At this time, one known *Lophelia* community has been located in LG100 although the entire area has not been explored. There will not be time for additional observations of the sea floor before your report is due so you will have to use your expertise to predict where other *Lophelia* sites may be. You must work with the information currently available and draw upon your expertise of *Lophelia* biology to help with this task.

We welcome any additional suggestions or ideas your group may have that might help us in developing a more comprehensive management plan for LG100 and other deep-water communities in the future.

Background Notes on BOEM and the OCS

The Bureau of Ocean Energy Management (BOEM), a bureau within the U.S. Department of Interior, is the federal agency responsible for overseeing the safe and environmentally sound management of offshore energy and minerals on the 1.76 billion acres of the Outer Continental Shelf (OCS). The OCS, defined by federal statute, refers to all submerged lands lying seaward and outside of the area of lands beneath navigable waters of each State. The OCS is a significant source of oil and gas for the Nation's energy supply. Approximately 43 million acres of the OCS account for about 15 percent of America's domestic natural gas production and about 27 percent of America's domestic oil production. The OCS is subject to the jurisdiction and control of the United States federal government.

Oil and gas companies interested in drilling for oil on the OCS must purchase a 5-year lease agreement through BOEM for access to the area they are interested in developing and then must apply for drilling permits to ensure compliance with regulations. More information on this process of leasing including a history of offshore petroleum exploration and development can be found at http://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Leasing.aspx.

To help protect the environment of the OCS, BOEM sponsors scientific research to understand the extent of ecosystems found there. Deep-sea coral communities, for example, have been studied extensively in the last 10+ years through independent research projects sponsored by this agency. In addition to adding to the scientific body of knowledge about deep-sea marine ecosystems, results from these research projects are used by BOEM's scientists to advise policy makers when making decisions about development of resources on the OCS.

Drilling Restrictions: Because drill sites typically discharge a great deal of mud and drill cuttings that can damage benthic communities and historic archaeological sites, BOEM currently provides strict guidelines for the placement of drilling platforms to ensure protection of sensitive sites. Drill sites may not be within 2000' of a sensitive site. Additionally, if the drill site platform has anchors, there must be an additional 1000' buffer surrounding anchor lines when in the area of a known sensitive feature.

Pinnacle Petroleum "Environmental Impact Assessment and Prioritization" Report Rubric

Your report should have the following components:

- Purpose of the environmental impact assessment and prioritization.
- Members of your scientific research group.
- General description of each exploratory drill site:
  - A general description of the site to include depth, topography of the area, and seafloor surface characteristics;
  - Distance to and description of nearby sensitive sites, or in unexplored areas, *potentially* sensitive sites;
  - With respect to potential *Lophelia* communities, description of suitability of site for deep coral community (i.e., potential for current flow);
  - Benefits and disadvantages of drilling at this site.
- Final recommendation of site with lowest potential for disturbing *Lophelia* communities or archeological sites (e.g., shipwrecks); your recommendation should be supported with evidence from the maps and from your understanding of *Lophelia* corals and coral communities. You should also indicate why the other sites are less desirable for drilling.

Report Rubric

4 - Exceptional	3 - Well Done	2 - Needs More Work	1 - Not Acceptable
Clearly states purpose that includes an explanation of importance of the report	Clearly states purpose for environmental impact assessment	Purpose for report is vague, incomplete, or misleading	Purpose for report is missing
General description of each site includes everything mentioned in 3-WellDone plus inferences about the current	General description of each of the five sites includes depth, seafloor surface characteristics, topography, and distance to nearest sensitive sites (shipwrecks, *Lophelia* communities or areas where *Lophelia* is likely to occur)	General description of each of the five sites is present but missing some information listed in 3-WellDone	Only two or fewer sites are described.

4 - Exceptional	3 - Well Done	2 - Needs More Work	1 – Not Acceptable
Presents recommendation for best site for petroleum exploration	Presents recommendation for best site for petroleum exploration	Presents recommendation for best site for petroleum exploration	Recommendation for petroleum exploration site is unclear or not present
Supports recommendation with evidence from 4 or 5 maps	Supports recommendation with evidence of seafloor surface characteristics, topography, possible effects of topography on currents	Supports recommendation with evidence from 1 or 2 physical features of the site	Does not support recommendation with information of physical features from maps
Clearly and directly connects recommendation with evidence from understanding of *Lophelia* biology and ecology	Supports recommendation with evidence from understanding of *Lophelia* biology and ecology	Mentions *Lophelia* biology and ecology but does not explain direct relationship to recommended location	Does not support recommendation with evidence from understanding of *Lophelia* biology and ecology
Presents evidence for remaining 3 or 4 exploration sites to explain why the areas should not be opened to exploration	Presents additional recommendation for an alternative exploration site supported with evidence from maps and *Lophelia* biology & ecology	No alternative exploration site presented	No alternative exploration site presented

Journey to the Bottom of the Sea Name: ___________

What would you see if you went to the bottom of the ocean?

In the list below, place an "X" next to each item that you think you could find on the bottom of the ocean if you were 500 meters (about 1600 feet) from the surface of the ocean on the bottom. Mark a "U" if you don't know what something is. Use the empty blanks to add anything you think you would find but isn't on the list.

____ rocks	____ fish	____ sharks	____ snails
____ people	____ seaweed	____ crabs	____ plants
____ corals	____ sea jellies	____ worms	____ flowers
____ trees	____ light	____ mud	____ shrimp
____ cold water	____ hot water	____ fishing nets	____ clams
____________	____________	____________	____________

In the space below, explain why you think you'll find the things you marked an "X" by on the bottom of the ocean.

In the space below, explain why you think you won't find each of the other things on the bottom of the ocean.

On the Bottom of the Gulf of Mexico **Name: __________**

Photomosaic Name or Number ______________________________

Organism Name & Number Observed	Description or Sketch of Organism (e.g., size, color, shape, sessile or motile)	Description of Habitat & Community Conditions (e.g., location, proximity to other organisms, substrate)	Notes

Conclusions on Patterns or Trends:

____

____

____

____

Coral Polyp – A Living Organism **Name: ___________**

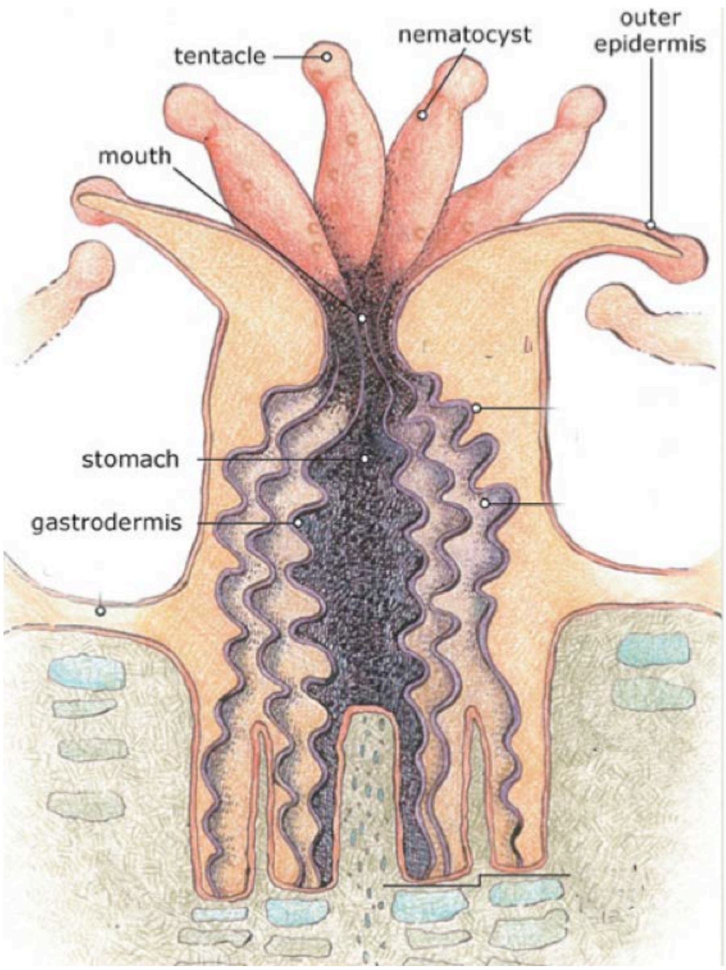
PREDICTIONS

Exchanging O_2 & C O_2:

Eliminating Waste:

Obtaining Water:

Reproduction:



Growth:

Consuming Nutrients for Energy:

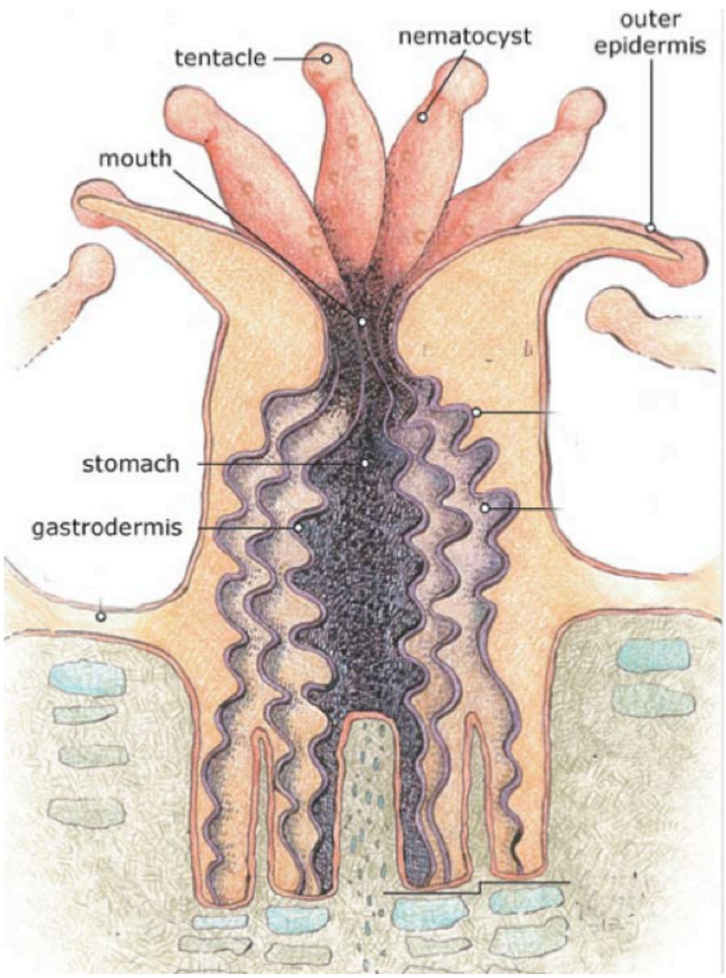
Responding to Stimuli:

Other notes and interesting facts about coral:

Coral Polyp – A Living Organism Name:____________
FINAL

Exchanging O_2 & CO_2:	Eliminating Waste:	Obtaining Water:

Reproduction:



Growth:

Consuming Nutrients for Energy:

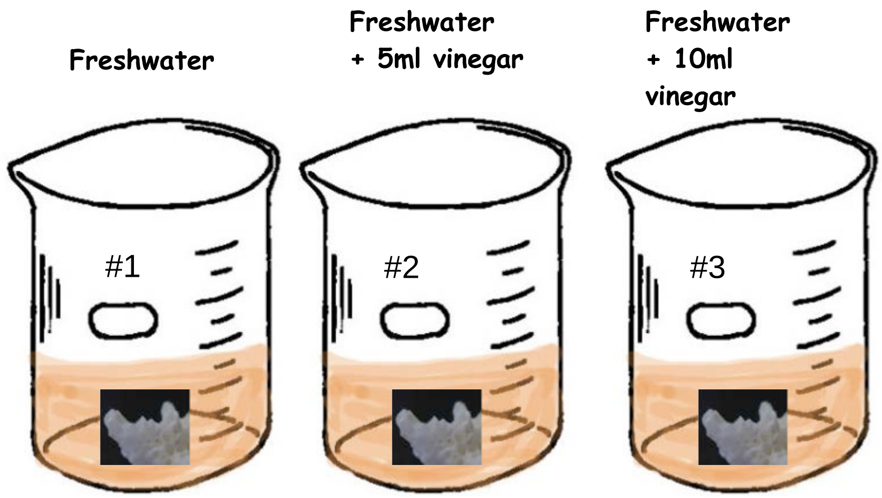
Responding to Stimuli:

Other notes and interesting facts about coral:

Ocean Acidification Experiment Name: ____________

Materials List (per group):

- 3 Beakers
- 3 petri dishes as lids
- Labeling tape & marker
- Fresh Water
- Distilled Vinegar
- Calibrated cylinder
- pH paper
- 3 coral pieces
- Paper towel
- Balance
- Tweezer (to handle coral pieces)
- Safety glasses (1 per student)



Procedure – Experiment setup and making predictions

1. Label each of your beakers with your group's name. Label beaker #!: "Freshwater" and beaker #2: "Freshwater + 5 ml Vinegar" and beaker #3: "Freshwater + 10ml Vinegar
2. Fill each beaker with 50 ml water. Add 5 ml distilled vinegar to beaker #2. Add 10ml distilled vinegar to beaker #3.
3. Measure the initial pH for each solution and record in the table below.
4. Measure the starting mass of each piece of coral, record on the table below, and then place one piece in each of the beakers.
5. Cover each beaker with a petri dish to minimize evaporation and set aside undisturbed for one week.
6. Write down your prediction of what will happen to each piece of coral after one week.

I predict the coral piece in Beaker #1 will____________________

I predict the coral piece in Beaker #2 will____________________

I predict the coral piece in Beaker #3 will____________________

Understanding what acidic solutions can do to coral skeleton

7. **While your coral pieces are in solution for the week, you will learn how corals make their skeleton and how CO_2 pollution is causing the pH of the ocean to change. At the end of the presentation, take a moment to re-evaluate your predictions and make any necessary changes.**
8. **At the end of the week, carefully remove the coral from solution and let it dry for 1 day. Be careful to keep track of which solution each coral piece came from. Working with one beaker at a time, carefully remove the coral piece from solution and place on a paper towel, discard the liquid and dry the beaker, and then place the coral piece back inside the beaker to dry for a day.**
9. **When coral pieces are completely dry, measure the ending mass of each piece of coral and record on the table below.**
10. **Calculate the difference between starting mass and ending mass and record in the table below.**
11. **You should also calculate the proportion of mass loss. This is equal to the difference between starting and ending mass divided by starting mass.**

	Beaker #1	Beaker #2	Beaker #3
Amount of water	50 ml	50 ml	50 ml
Amount of Vinegar	0 ml	5 ml	10 m
Initial pH of solution			
Initial mass of coral piece (gm)			
Ending mass of coral piece (gm)			
Difference in mass (final – initial) (gm)			
Proportion of mass loss (difference / initial mass)			

Reflection Questions:

1. Write down the chemical equation for calcification (from the PowerPoint presentation). Include names for each chemical formula.

2. Where does this calcification take place? (from ppt)

3. How close were your predictions to what actually happened to each coral piece? Be specific.

4. How is this experiment similar to the real world?

5. How is this experiment different from the real world? List as many differences as you can think of. Hint: are these pHs realistic for ocean water?

6. Pick one of the items listed as a "difference" and design an experiment to test the effect of that variable on coral. Describe your experiment here. Be certain to label the independent and dependent variables.

Understanding what acidification can do to polyps:

7. One of the key differences between this classroom experiment and the real world is that only the coral skeleton is exposed to the acidic solution. In other words, the living polyp is not part of the experiment. What do you predict would be the effect of acidification on the coral polyp? Would it still make its skeleton?

Understanding what acidification may do to *Lophelia*:

Read the essay titled "*Exploring the C's: Climate Change and Cold-water Corals*" by deep-sea scientist, Jay Lunden from Temple University, found on the NOAA Ocean Explorer website:
http://oceanexplorer.noaa.gov/explorations/09lophelia/background/climatechange/climatechange.html

8. What two factors does Jay identify as potentially changing the environment in which *Lophelia* is found?

9. Pick one of these factors and describe how it may directly affect the deep-sea coral, *Lophelia pertusa.*

Deep Ocean Currents Experiment   Name:____________

Experimental Set-up
(Draw a diagram of your experimental set-up with tub, siphon, 1000mL beaker, etc)

Model	**Real World**	**...because**
The **tub of water** is like		because they both have large volumes of water.
The **fish food flakes** are like		
	deep ocean currents	

List the type of landforms you can test in your model ocean. Circle the one you will test.

In the space below, draw the type of ocean bottom landform you will test as it will look in your model ocean.
Side View: Top View:

Investigative Question: What is the effect of different landforms on the distribution of particles (fish food flakes) that fall through the water from the surface when there is a current on the bottom?

Hypothesis:

Procedures:

1. Fill your tub half full of water. Mark the water level on the outside of the tub using a wax pen or marker. Fill your beaker (or other container) with 1000mL of water.
2. Practice creating a current in the tub without the landform. Sprinkle half a teaspoon of fish flakes across the surface so they are distributed as evenly as possible. Let them float for 30 seconds. Then, practice poking them so they fall to the bottom.
3. Conduct the experiment. Try to do everything exactly the same way each time (sprinkling the fish flakes evenly across the surface, poking the fish flakes so they sink, holding the tube in the same place to create a current).
4. Complete the table below using words and pictures to show where the fish flakes land on the bottom under each condition.
5. Clean up your materials when you are finished. Answer the reflection questions below.

Distribution of Fish Food Flakes (use words and pictures to show their location)

Landform	No Current	Current
Flat Bottom		

Reflection Questions:

1. Describe the distribution of the fish food flakes when there is **no current** in the tub.

2. Describe the distribution of the fish food flakes when there **is a current** in the tub.

3. Imagine that your model ocean has *Lophelia* corals somewhere on the bottom. How might <u>deep ocean currents</u> affect:

   a. availability of food

   b. sexual reproduction

   c. formation of new colonies

3. How well do you think you understand deep ocean currents after completing this activity?

4.What questions do you have about deep ocean currents?

Assignment: Create a comic strip or storyboard that illustrates possible effects of currents on *Lophelia.*

Rubric for Comic Strip

	4	3	2	1
Content	Includes everything in Level 3 plus: ___ Describes the biology of *Lophelia* in relationship to the effects of currents (for example, feeding, sexual reproduction, exchange of Oxygen and Carbon Dioxide)	___ Shows effects of currents on the dispersal of larvae ___ Shows effects of currents on availability of food ___ Shows effects of currents on the presence of hard surfaces ___ Content is accurate	Omits 1 or more of the criteria in Level 3	Omits 2 or more of the criteria in Level 3
Presentation	___ Includes color ___ Neatly done ___ Easy to read	___ Easy to read	Not neatly done	Not easy to read
Due Date	___ Turned in on time	___ Turned in on time	___ Turned in on time	Turned in late

(Optional)

Investigative Question: What is the effect of different landforms on the speed of water flowing around them?

Hypothesis:

Procedures:

1. Measure a distance from just in front of the tube creating the current to almost at the back of the tub. Mark this distance on the side of the container or on a piece of paper that you put under the tub.
2. Use the stop watch to measure the length of time it takes a small particle of fish food to travel the distance.
3. Calculate the speed of the particle by dividing the distance by the time.

Speed=distance (cm)/ time (sec)

Speed of Water

Landform	No Current	Current
Flat Bottom		

Reflection:

1. Where is the speed of a particle the fastest around the landform you created?

2.Where is the speed of a particle the slowest around the landform you created?

Living in Lophelia's Neighborhood **Name: ____________**

Warm-up:

Draw a diagram of one atom of either ^{12}C, ^{13}C, ^{14}N, or ^{15}N:
(your teacher will tell you which one to draw.)

$^{12}_{6}\mathrm{C}$	$^{13}_{6}\mathrm{C}$	$^{14}_{7}\mathrm{N}$	$^{15}_{7}\mathrm{N}$

Part 1: Tools to Study a Community's Food Web (Slides 1-8)

1. Using your prior knowledge of cold-water coral communities, construct a food web of the *Lophelia* community. Use these organisms: *Lophelia* coral, sponge, crab, hydroids, fish, and brittle stars. *(Let the pictures in the third slide help you.)*

2. As an ecologist, how could you determine who eats whom? What could you do?

My Ideas	**Techniques Used by Ecologists** *(from slides)*

Part 2: Carbon Isotope Analysis (Slides 9- 24)

3. Predict whether the following statements are True or False. Then, as you go through the slides with your teacher, give your final answers and then reword any false statements so they are true.

Prediction (T or F)	**Statement**	**Final Answer**
	A) Scientists have tools that can measure the amount of Carbon 12 (^{12}C) and of Carbon 13 (^{13}C) in different organisms.	
	B) Plants use equal amounts of ^{12}C and of ^{13}C during photosynthesis.	
	C) Plants are known as consumers and animals as primary producers.	
	D) Scientists can analyze a steak to determine if the cow the steak is from ate more corn or grasses (like wheat).	
	E) Carbon 13 (^{13}C) values give us information on the source of carbon for different organisms.	

4. Listed below are different living and non-living objects that contain Carbon and its average converted value of ^{13}C, called $\delta^{13}C$. Put the objects in order from highest proportion of ^{13}C to lowest proportion of ^{3}C. *(Note – use after slide 15 but before looking at slide #19)*

   Air: $\delta^{13}C$ = -7
   Carbon stored in the soil: $\delta^{13}C$ = -23
   Corn: $\delta^{13}C$ = -12
   Cow in Brazil: $\delta^{13}C$ = -11.6
   Cow in Britain: $\delta^{13}C$ = -25.5
   Lophelia: $\delta^{13}C$ = -22
   Wheat: $\delta^{13}C$ = -25

   Explain how you decided which item had the smallest proportion of ^{13}C .

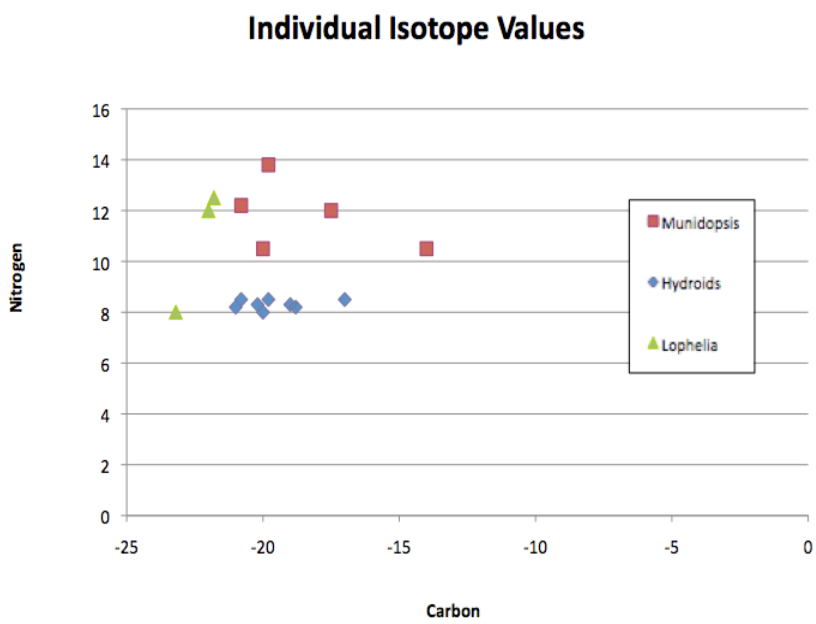
5. Explain what the phrase **“You are what you eat”** means using Carbon as an example.

Part 3: Nitrogen Isotopes & Trophic Levels (Slides 25-27)

6. In your own words, explain why it’s necessary to use BOTH Carbon and Nitrogen isotope values to figure out “who eats what” in a food web. Think about what Carbon isotope values tell us, and then what Nitrogen isotope values tell us.

Part 4: Sorting out *Lophelia's* Food web (Slides 28-35)

1. Using this graph, write down at least three trophic relationship patterns you see in this dataset.



2. After reviewing the slides and class discussion, record any new or revised patterns you now see in this dataset.

3. In the *Lophelia* community food web, …

a. which organisms shown in the slides are at the lowest trophic level?

b. who are the primary producers and where are they in the marine environment? How do they get to the *Lophelia* community?

c. which organisms are at the highest trophic level?

d. which organisms are full-time residents vs. those that are visitors?

e. how does this community interact with the larger marine ecosystem?

f. how important do you feel these deep coral communities are?