Lesson 6 OA Jigsaw Close Reading: *"*Blooming diatoms: *Ocean gardens a nutrient balancing act"*
An exercise in integration of data and systems thinking

Introduction to Jigsaw:
We know pH increase or decrease causes a change in the ocean system. We also know that this affects population size of two organisms in different ways (death and rate of growth). Given this:

- *What could the reverberating effects of their death be?*
- *What could the reverberating effects of their change in growth rate be?*

This is what we want to find out: *If there is an increase or decrease in the population of diatoms what affect could it have on other organisms in the system? If the population is decreasing (therefore unable to continue to fix carbon at the same rate) what is the effect on the system as a whole (e.g. available oxygen, carbon and available nutrients) ? What organism(s) is/are affected by the imbalance in the system?*
We know the basic answer: *The single-cell, photosynthesizers are using vital energy they would normally use for growth to collect the carbon they need. When there is less carbon and more H+, the resource becomes a limit to their growth rate. But, how might a change in their growth rate affect overall ocean productivity? In other words what effect is there on the oxygen, carbon and other nutrients they provide to the ocean carbon system? What are the building blocks of cells in living organisms? Besides carbon and oxygen, there are essential nutrients (N, P, Si, Ca and Fe). All are considered* ***limiting nutrients.*** *If the ratio of nutrients in ocean water changes it affects how well organisms can grow. Think about the carbon cycle, eutrophication, and competition among organisms for essential nutrients. Scientists agree the baseline ratio of these nutrients exists in ocean waters. They can make predictions and collect data to find out how a change in the nutrient ratios affects the system as a whole. The perturbations in the balance of the essential building materials cause a chain reaction in the global carbon system. As you read the article think about the carbon cycle, and these nutrient building blocks in the ocean system.*

Step 1: Before you begin the Jigsaw activity **THINK and WRITE:** What could be an effect on the ocean system network if one population increased or died off at a greater rate?

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Directions:

1) Groups of 3-4 students read and complete a systems analysis for their 2-3 assigned pages of the article: *"***Blooming diatoms: Ocean gardens a nutrient balancing act"**
2) Using the article identify, draw and label the edges and nodes that are described for the system.
3) As a class present your research, and combine these system diagrams into one interconnected ocean system network diagram.
4) Trace the perturbation through the network diagram of nodes, look for and find the nodes that would be affected if an **increase** or **decrease** of the **nutrients** occurs.

Link downloadable (optional): *Student Reading Guide: "***Blooming diatoms: Ocean gardens…"**

As you read THINK:

1) "Why is this happening to diatoms?"
2) "What effect does this have on other nodes and the larger global system?"

Goals -- At the end of the jigsaw you should be able to:

1) Identify a node change that can lead to **increasing** carbon **availability** in the ocean system or **increasing** carbon **export** to the bottom.
2) Describe a node change that leads to a) **increase** or b) **decrease** in **oxygen** levels because of phytoplankton population changes or because of bacteria activity.
3) Describe how a change in the **amount of available nutrients** (N, P, Si, Fe, etc.) occurs when CO_2 is **increased**. Trace the potential effect **increases** or **decreases** have on populations of other organisms.
4) Describe specific nodes to give an example of what happens when specific **phytoplankton die at an increased rate.**

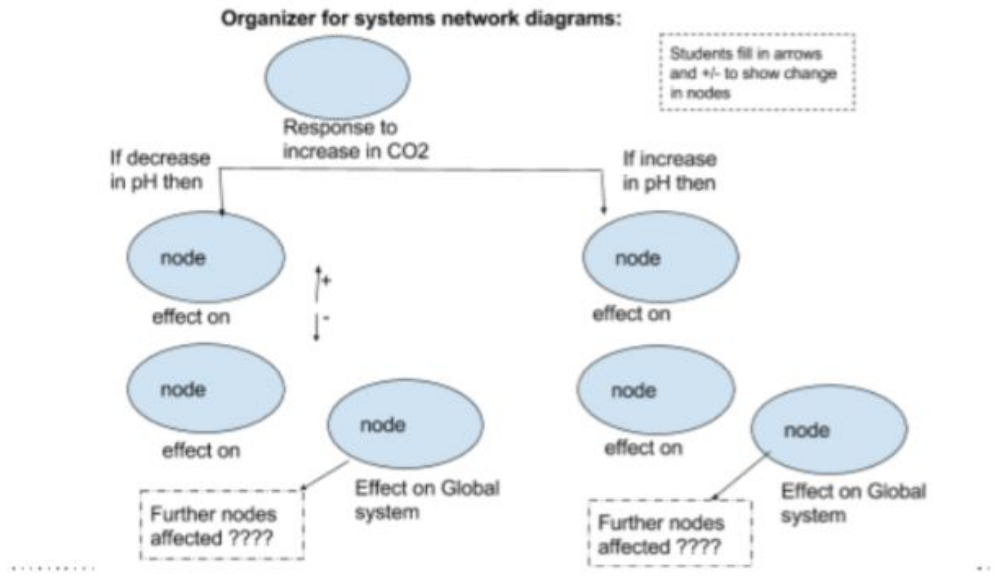
Step 2: Circle any words you do not know. Add them to a vocabulary student guide. Next use a science dictionary or other resource to write down the meaning. Here is an example:

Scientific Word	**Scientific Meaning (determine appropriate definition based on context**
upwelling	
uptake	
$CaCO_3$	
Re-mineralize	
eutrophication	

Step 3: Write down any system nodes and reactions to changes that are described, using a systems network diagram. Use arrows for a) **inputs** and b) **outputs**, and use (+) for **increase** or (-) for **decrease.** Connect the nodes as completely as you can. Be on the lookout for place where perturbations may tip the balance point of homeostasis in the system. **Ask:**

A. Is there increase or decrease in a specific population due to the perturbations?
B. If the population is increasing/decreasing - what effect does it have on other nodes?
C. If the population is increasing/decreasing--therefore unable to fix carbon at the same rate-- what is the effect on the system as a whole?
D. If the pH is changing--therefore unable to fix carbon at the same rate-- what is the effect on the oxygen and what is the effect on the nutrients available for other organisms to use?

Below is an example:



(Image credit: B. Steffens, ISB)

Step 4: Post your network diagrams on sticky notes or cards to share on the systems network diagram. Present your findings. Answer the following after you have heard from each group.

1. Identify and describe a node change that can lead to increasing carbon availability in the ocean system or increasing carbon export to the bottom.

2. Draw and trace a node change that can lead to lower or higher oxygen levels. These changes can be as a result of phytoplankton population (+/-), or an increase in oxygen use as a result of prokaryotic decomposing and re-mineralizing. Describe the perturbation and its effects.

3. Find an example of how a change in the amount of available nutrients (Si, N, P, etc.) occurs when CO_2 is increased. Describe the effect of the population changes on other organisms.
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4. Describe what happens when Phytoplankton die.
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Step 5: Final analysis of the system

*Respond to the analysis questions in your science journal. Use evidence from your in-class experiments and NetLogo simulation, along with the insights you have gained by reading "***Blooming diatoms: Ocean gardens a nutrient balancing act"** *to support your answers.*

1. Where does the Ocean Acidification NetLogo model simulation you completed (Lesson 6) fit into the ocean system network diagram?
2. How do your claims and evidence--(from Lesson 5a)-- fit into the ocean system network model?
3. a) If we increase the CO_2 level what is the effect on the diatoms? Why?
   b) If we increase the CO_2 level what is the effect on the coccolithophores? Why?
4. If ocean acidity increases, what effect does this have on available dissolved carbon in the ocean?
5. When a phytoplankton population, like diatoms, is dying at a faster rate, what is a direct effect on the available oxygen for the ocean system network?
6. As CO_2 increases, what effect does this have on O_2 production in the ocean system? Why?
7. Where do nutrients come from to supply the ocean system?
8. If diatoms die off at a faster rate, what happens to the available nutrients in the ocean system?
9. CO_2 increase has an effect on the pH of the ocean system. Describe two examples of perturbations in the Ocean System Network model that can result from the change in pH?
10. Describe three examples of nodes that may affect the uptake of *available nutrients*?
11. Describe three examples of nodes that may affect the amount or kinds of *available nutrients*?
12. What occurs if Fe becomes less available? How could this perturbation to the system affect the production of global oxygen?
13. What happens to nodes in the system if phytoplankton grow and then die at a higher rate?
14. What might cause reduced available nutrients in the ocean system? Make at least two claims and give evidence for your claims.
15. If we increase the CO_2 level and coccolithophores increase their growth rate, what are two possible global effects on the environment? (HINT: Think of nodes linked to the ocean system)

Extension Questions:

1. As ocean temperature, available nutrients and light changes, oxygen availability changes as well. Explain the role of *upwelling* in the system, and list three effects that could occur.
2. Besides ocean acidity in general, what are three recurring reverberations on the ocean system resulting from increases in CO_2?
3. What are two forms carbon can take in the ocean? How is carbon made available for other organisms? Why do they need carbon?
4. Respond to the statement using evidence: "What dies is more important than how it dies."

Step 6: Summative Assessment--This is what I learned *(Hand in exit slip or in-class essay to your teacher)*

1. This is what I knew:
2. This is what I wanted to find out: The silica-shelled diatoms and the marine calcifiers are winning, making nearly half of all the world's oxygen. Will they both continue to be winners as the system continues to change? Predict what will happen as ocean acidification rises.
3. This is what I learned: Did your responses change from your original ideas at the start of this activity? Explain why or why not and how?