

# Teaching Notes *for*

## A Case Study on Ocean Acidification

By  
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### INTRODUCTION / BACKGROUND

This case study intends to evaluate freshman students understanding of the scientific method. As an effort of incorporating new topics into the college-level curriculum, the following case study will explore the topic of ocean acidification within the sustainability context. This case was used on a Introduction to Chemistry class and can be use as necessary in any natural science or other appropriate disciplines.

This case study is based partially in the article: Hall-Spencer J.M., et. al. Volcanic carbon dioxide vents show ecosystem effects of ocean acidification. *Nature Letters* , 1-4 (2008). doi:10.1038/nature07051. In addition, other resources were put together to simplify the socio-environmental systems for the students.

### **Objectives**

Upon completion of this case study, students should be aware of the following:

- Students will identify some of the steps of the scientific method.
- Based on the definition of sustainability, they should describe the socio-environmental problem of ocean acidification.
- Analysis and interpretation of scientific data in graphical form.
- The diverse ways in which the same set of scientific data may be interpreted by groups having differing political and economic viewpoints.
- Ability to identify potential users of the research findings.

### CLASSROOM MANAGEMENT

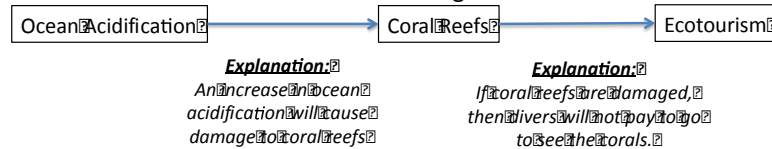
This case is taught using a combination of a flip classroom and interrupted case study during a 50 mins class. Before the case study, students should have read the book (or any resource provided by the instructor) concerning the topic of the scientific method. At this level students should be warned that a quiz will be given during lecture to encourage their prior preparation.

- *Challenges/Opportunities:* This is our second meeting of the semester. Most of my students are not use to get prepared before a class. To make sure that most of them had read the basic concepts of the scientific method they completed an online quiz (see example questions at the end)

The case study is given to four-person student teams. The teams are asked to read the first page and answer questions 1 to 3. Because the students are not used taking to each other at this point of the semester, the instructor should be walking around to encourage the discussion among team-peers. After around 10 mins. the instructor shows a slide with the definition of sustainability (See Figure 1.) and starts writing on the board all socio-economic connections that the teams suggested Depending on the suggestion a discussion will be encourage to start connecting them all (See Figure 2).

- *Challenges/Opportunities:* because this is an introductory level class it takes time for the students to actually believe that some of the connections maybe examples that are not included in the reading. This is a great opportunity to encourage them to make connections with their daily life like going to the restaurant or the farmers market. It is suggested to discuss an example that is compelling to you. I love to scuba dive so I used the following example. I first write the socio-

environmental factors and then ask the how they are connected. The direction of the arrow goes from the factor to what will be affected by it. This should be brief for the sake of time management.



One of the objectives for socio-economical connection exercise is for the students to understand that sustainability creates and maintains the conditions under which humans and nature can co-exist in productive harmony while meeting the needs of society, economy and other requirements of present and future generations. However, affecting the environment can affect our social and economical conditions. This discussion should not take longer than 10 mins.

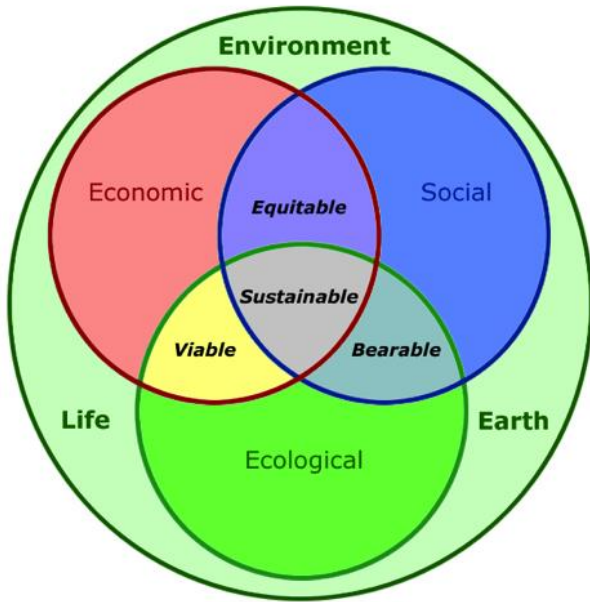


Figure 1. Diagram explaining all the components for sustainability

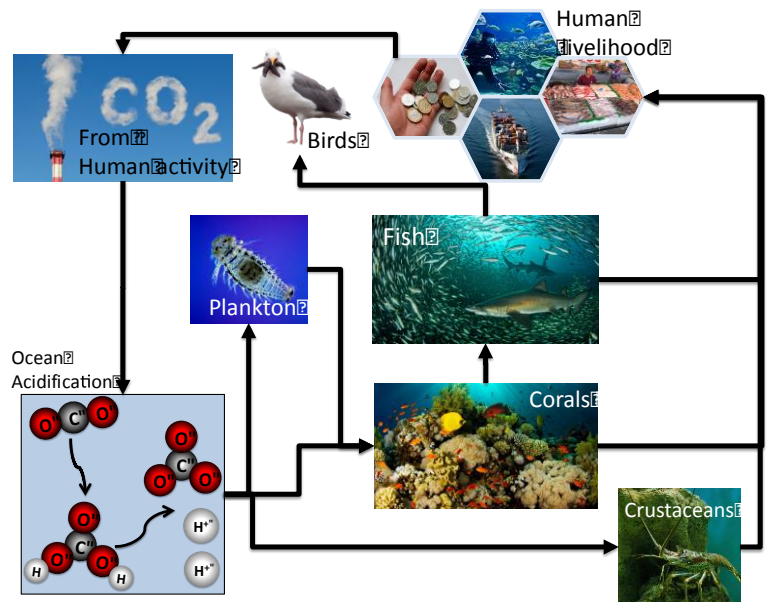


Figure 2. Example diagram for socio-economic connections

Students are asked to continue reading page 2 and answer the rest of the questions in the handout. After 15 mins, they are asked to handle their answers to the instructor. After collecting the they are asked about weather they agree or not with the outcome of the results from the research study. They are asked if they might need more information (speculate about what type of information) to get a better conclusion. With this, we end up reviewing the steps of the scientific method and how circular non-linear is the process. We emphasized in the difference between a natural law and theories using the case study as an example.

- Challenges/Opportunities:** Students have a hard time using the definitions for observation, procedure, results and conclusion in this type of context. This is a great opportunity to hear their answers about who will be affected by the problem. They cannot think that the problem of ocean acidification may affect them directly. Some of them had never hear of this problem before and for the first time they can tide the CO<sub>2</sub> increase in the environment with something other than global warming. I was impressed to see students concerned and actually suggesting how they can help. Some of them felt frustrated that they cannot help at all. For me it was a great opportunity to provide value to my class. I told them that some of you may become scientist to help to solve this type of problems, some of them will try to make changes on their daily life, but all of them will probably become tax payers. So they need to know chemistry to be able to understand where to put their money and the problem may be solved.

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## REFERENCES / RESOURCES

- 1) <http://www.sustainability.org>; <http://www.epa.gov/sustainability/>;  
<http://www.acs.org/content/acs/en/sustainability/acsandsustainability.html>
- 2) <http://www.st.nmfs.noaa.gov/st1/index.html>
- 3) NMFS statistics, accessed October 2013. NMFS statistics and Andrews et al 2008.
- 4) Cooley S.R., and Doney S.C. (Anticipating ocean acidification's economic consequences for commercial fisheries. Environ. Res. Lett. (2009).

### Example questions for quiz before the case is discussed.

1. Which statement about the scientific method is TRUE?  
A) The scientific method emphasizes reason as the way to understand the world.  
B) The scientific method emphasizes observation and reason as the way to understand the world.  
C) The scientific method emphasizes observation and experimentation as the way to understand the world.  
D) The scientific method emphasizes scientific laws as the way to understand the world.  
E) All of the above statements are false.

Ans: C

2. A summary of experimental data is a  
A) hypothesis.      B) law.      C) theory.      D) prediction.      E) measurement

Ans: B

3. Which of the following is an example of a scientific theory?  
A) All matter is composed of small, indestructible particles called atoms.  
B) In a chemical reaction, matter is neither created nor destroyed.  
C) When a can of soda pop is opened, a fizzing sound is heard.  
D) Flammable objects contain phlogiston.  
E) none of the above

Ans: A

4. A dictionary has the following definition for a word: "A tentative explanation that accounts for a set of facts." Which of the following words best fits that definition?  
A) theory      B) hypothesis      C) law      D) experiment      E) definition

Ans: B

5. What is the definition of a scientific theory?  
A) a brief statement that summarizes past observations and predicts future ones  
B) a model that explains the underlying reasons for observations and laws  
C) the equivalent of a scientific opinion which others may disagree with  
D) a method of learning that emphasizes reason as the way to understand the world  
E) none of the above

Ans: B