Anytime Lesson: Ocean Acidification Mock Conference

GRADE LEVELS	7th – 12th; CA Content Standards 7, 8, 9-12
SUBJECTS	English-Language Arts, Chemistry, Biology, Earth Sciences
DURATION	Preparation: 5 minutes Activity: 105 minutes (2 periods)
SETTING	Classroom

Objectives

Through this lesson, students will:

1. Learn what organisms are affected by ocean acidification
2. Take on the role of one of the stakeholders affected by ocean acidification
3. Create poster(s) to address their issue(s)
4. Participate in a mock conference to address the affects of ocean acidification
5. Discuss solutions to reduce ocean acidification

Materials

Stakeholder Cards (classroom set)
Conference Directions Sheet – 1 per group
Poster paper (one per group)
Markers, colored pencils, or crayons (set per group)
6 envelopes with one blank paper taped to the outside and 5 blank papers inside
Scratch paper

Vocabulary

- **calcifier:** an organism that builds a calcium carbonate shell or skeleton
- **calcium carbonate**: the basic material of which most marine shells and some skeletons are made
- **carbon dioxide:** a chemical compound composed of two oxygen atoms bonded on either side of a carbon atom. While naturally occurring in our atmosphere, carbon dioxide is also the by-product of the combustion of fossil fuels, emitted from car engines, coal power plants, and other producers of exhaust. Carbon dioxide is a greenhouse gas.
- **green house gas:** gases in the atmosphere that absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect.
- **ocean acidification**: the process by which carbon dioxide dissolves in seawater causing a decrease in pH. To learn more, see 'Teacher Background.'

Teacher Background

What is ocean acidification?
Recently, scientists have discovered that the chemistry of the ocean is changing. Because of higher levels of carbon dioxide (CO_2) being released into the atmosphere, more carbon dioxide is being absorbed by the oceans than ever before. This diffused CO_2 undergoes a chemical reaction that forms carbonic acid, which lowers the pH of seawater in the process called ocean

acidification. (Remember that acidity and pH are inversely related; the lower the pH, the more acidic the solution.) This acidification leads to a reduction of available carbonate ions that form calcium carbonate, the material many marine organisms use to create their shells and skeletons. Not only does acidification make it more difficult for these animals to make their shells, but it also can lead to the weakening or destruction of already formed shells (Australian Academy of Science, 2008; Guinotte & Fabry, 2008; Orr, et al, 2005; The Royal Society, 2005; Usha 2006).

There are natural fluctuations in the flow of carbon dioxide throughout the atmosphere and the oceans. However, since the industrial revolution humans have been increasing the rate at which carbon dioxide is released. The largest source of this increase is due to the burning of fossil fuels, which releases CO_2; however, other actions such as deforestation also contribute to CO_2 release. As carbon dioxide is released in the atmosphere, the ocean acts to restore equilibrium between the concentration of CO_2 dissolved in the water and that which is present in the air, acting as a carbon dioxide sink that absorbs this greenhouse gas. In fact, around one quarter of the CO_2 released into the atmosphere each year is absorbed by the ocean[1].

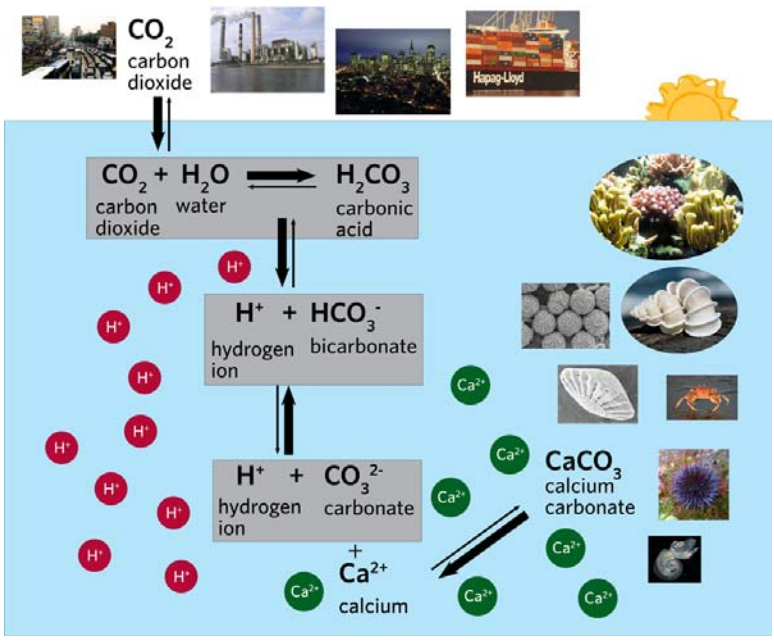


Diagram (left): Under normal conditions in ocean water between a pH of 7.9-8.2, the ionic forms of carbonic acid are present mostly in the forms of bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). The water is "saturated" with as much carbonate as it can hold, so organisms can easily combine carbonate ions and dissolved calcium ions – which are also in regular supply – to create calcium carbonate shells and skeletons. However, under the more acidic situation represented in the diagram the equilibrium reactions shift in the directions indicated by the thicker arrows. Notice how carbonate is being taken up by all the excess hydrogen ions, making carbonate less available to organisms.

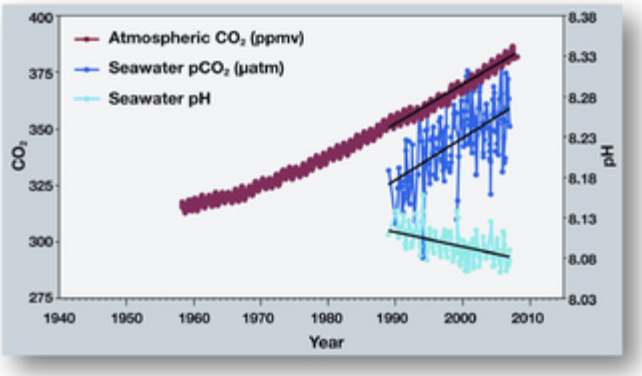
Some of the carbon that is dissolved into seawater from the atmosphere is taken up by photosynthetic organisms such as phytoplankton and algae during photosynthesis (just as it would be on land by plants). The remainder of the carbon dioxide diffuses into the ocean and becomes part of a complex series of acid-base equilibrium reactions. In a healthy system of ocean water at a pH around 8, this absorption of carbon dioxide by seawater leads to the creation of a relatively large amount of bicarbonate (HCO_3^-) ions and a relatively small amount of carbonate ions (CO_3^{2-}). Organisms then use this carbonate, along with the calcium (Ca^{2+}) also dissolved in seawater to create their calcium carbonate ($CaCO_3$) skeletons and shells. Unfortunately, the excess of carbon dioxide being absorbed by the oceans is leading to a drop in

[1] The Ocean in a High CO_2 World Symposium, Summary for Policymakers 2009 http://www.ocean-acidification.net/OAdocs/SPM-lorezv2.pdf

pH, or increased acidity of seawater, which tips the acid-base equilibrium to favor the formation of bicarbonate (HCO_3^-) ions. As pH lowers, the scale continues to tip, this time in favor of more carbonic acid (H_2CO_3). This limits organisms' access to carbonate ions (CO_3^{2-}), which are needed to form their calcium carbonate ($CaCO_3$) shells and skeletons. A good description of what is occurring chemically can be found here: http://theotherco2problem.wordpress.com/what-happens-chemically/.

How has the ocean changed over time?

Ocean acidity has increased by 30% since the beginning of the Industrial Revolution. This increase is 100 times faster than any change in acidity experienced by marine organisms for at least the last 200 million years. Half of this increase has occurred in the last 30 years.[2] This increasing rate of acidification has implications for marine life.



This graph shows the correlation between rising levels of carbon dioxide (CO_2) in the atmosphere at Mauna Loa with rising CO_2 levels in the nearby ocean at Station Aloha. As more CO_2 accumulates in the ocean, the pH of the ocean decreases. (Modified after R.A. Feely, Bulletin of the American Meteorological Society, July 2008)

How does ocean acidification affect marine life?

Many shells and skeletons are made up of calcium carbonate and grow continuously throughout most animals' lives. These protective coverings allow animals to survive attacks by predators and withstand harsh conditions. Shells are a necessity of life for these animals. Furthermore, many animals with shells, such as certain types of plankton and many mollusks, are found near the bottom of the ocean food chain. Three kinds of plankton, cocolithophores, pteropods, and foraminiferans, have calcium carbonate shells. Without essential carbonate, these organisms wouldn't be able to grow, reproduce, and be food for other organisms. As a result, declines in their population have the potential to impact the animals that depend on them for food and serve as an indicator of the health of ocean environments.

How does ocean acidification affect us?

The increasing acidity of the ocean affects us in a few major ways. Around 5% of the world's protein comes from the oceans through fishing. Because many of the organisms in the bottom of the food chain have calcium carbonate skeletons, a decrease in these populations has the potential to decrease the populations of animals higher up in the food chain as well.

Corals are animals that also have calcium carbonate skeletons. If corals did not have the carbonate needed for them to create their skeletons, they would not be able to continue to build the coral reefs that many game fish use as their home or hunting grounds. Many of the marine

[2] *Ocean Acidification: A summary for policymakers from the second symposium on the ocean in a high-CO_2 world* (2009)

animals that we eat (fish, shellfish) are therefore either directly affected, or indirectly affected by increased acidification.

In addition to affecting our food supply, increased acidification can affect how we use the ocean for recreation. Many tropical countries rely on tourism to their coral reefs. Without carbonate, these coral reefs would begin to decline, potentially causing a drop in tourism. Not only would the economy suffer, but people wouldn't have this recreational outlet. Many people and cultures have a deep connection with the ocean and this connection will be threatened as the health of the ocean continues to decline.

What is causing ocean acidification?

Ocean acidification is occurring due to the increased amount of CO_2 in the atmosphere. Carbon dioxide exists naturally in the atmosphere (for example, we breathe our CO_2). However, human activity has been increasing the amount of carbon dioxide in the atmosphere since the industrial revolution through the burning of fossil fuels such as coal and oil. Fossil fuels currently provide more than 85% of all the energy consumed in the US. Almost half of our electricity is from coal burning power plants, and virtually all of our transportation relies on the burning of fossil fuels[3].

What are misperceptions people may have regarding ocean acidification?

Note that the term ocean acidification refers to the process of the lowering of the ocean's pH level, not the end state of the ocean turning into an acid. Depending on location and conditions, ocean pH currently stands in the high 7s and low 8s, and should not fall below 7. Why? Because each year, the oceans experience runoff of alkaline substances from the land, adding base that neutralizes some of the acidity. The problem arises around the ion equilibrium for carbonic acid at a pH of 7, which disfavors the carbonate ion form. One could even refer to ocean acidification as the process that makes ocean water "less basic or less alkaline."

What is being done currently?

Ocean acidification and its impacts have only recently come into the public eye and is a relatively new area of study. An informal review of literature available online resulted in the following list of actions being done to either learn more about ocean acidification and its effects or directly affect the amount of CO_2 being released in the atmosphere. The following items were found to be true as of January 2011, but keep in mind that the field is progressing and changing rapidly. A search using your favorite search engine for 'ocean acidification' will give you a wealth of information on the topic. As with any search, use reputable resources.

<u>Research and Development</u>

- Increase efforts to study the effects of increased acidification of the oceans on marine life
- Increase the amount of money spent on developing renewable energy sources

<u>Government Involvement and Regulation</u>

- Regulate carbon dioxide emissions
- Require businesses to determine the amount of carbon dioxide they produce
- Sign an international treaty to reduce greenhouse gas emissions

[3] US Energy Information Administration Annual Energy Review August 19, 2010

- Create policies that would require a reduction in the amount of carbon dioxide emissions from businesses
- Require automakers to increase fuel efficiency to 45 miles/gallon
- Allow companies to buy and sell the right to emit greenhouse gasses. The federal government would set a national cap on emissions and each company would then purchase the right to emit a portion of this total amount. If a company emitted more than its portion, it would have to buy more emission rights from other companies or pay large fees.

Individual Level

- Make personal choices to reduce personal contributions to carbon dioxide emissions and encourage others to do the same
- Contact elected officials to urge action on global warming
- Institute a gasoline tax
- Provide tax rebates to individuals who purchase solar panels or fuel-efficient vehicles

Activity

Preparation

1. Create six groups of students, one for each stakeholder group: Organisms, Fishing Industry, Energy Companies, Transportation Industry, Recreation/Travel Industry, and Representatives from the Public.
2. Print out one set of *Stakeholder Cards*. Each group will get the card associated with their group. For example, the Fishing Industry will receive the "You are: Representatives of the Fishing Industry" card. **if groups are large, you may wish to print out more than one set so that students aren't crowded around one card.*
3. Print out *Conference Directions Sheet* (one per group).
4. We recommend breaking up the activities so that the first day focuses on preparing for the conference (introduction and creation of poster and presentations), reserving the second day for the actual conference, presentations, and class discussion.

Introduction: Day 1 (15 minutes)

How does ocean acidification affect marine life?

- Explain to the students that the chemistry of the oceans is changing. Seawater is generally slightly basic, but due to human activity, the oceans are becoming slightly more acidic.
- Ask students what it means for something to be acidic. You can get as in depth with your students as appropriate depending on their level of understanding of acid base chemistry. In the very least, discuss how acids often have a corrosive or dissolving effect.
- Explain that while the oceans are becoming more acidic, they are only becoming slightly more acidic.
- Ask students to Think-Pair-Share: What kinds of animals are in the ocean? Have students share their responses. As they share, write their responses on the board, but group them so that all of the organisms that are on one side are calcifiers (organisms that have a calcium carbonate shell or outer skeleton) and all of the

other organisms are on the other side. **use the Organisms Stakeholder Card to brush up on your calcifiers!*

- After you have grouped the organisms, ask students to guess how you have grouped them (organisms directly affected by a more acidic ocean – calcifiers), and what characteristic they have in common (*create calcium carbonate shells or external skeletons).* Explain that as seawater becomes more acidic, the building blocks (*carbonate*) for these animals become less available. With an increasingly acidic ocean, these animals won't be able to make their shells or grow.

<u>What is causing the oceans to become more acidic?</u>

- Ask students for any guesses as to how the ocean is becoming more acidic (*increase of carbon dioxide in the atmosphere primarily due to the burning of fossil fuels*). Give them a few hints such as:
  - it has been increasing since the industrial revolution,
  - it is something humans are doing,
  - an airplane contributes to it when it flies,
  - drivers contribute to it when they drive,
  - depending on where they live (not all energy plants are coal-burning plants), when they turn on the light or their computer, they may also be contributing.
- Explain that when the carbon dioxide dissolves in the water, this diffused CO_2 undergoes a chemical reaction that forms carbonic acid, which lowers the pH of seawater in the process called ocean acidification. This acidification leads to a reduction of available carbonate ions that form calcium carbonate, the material many marine organisms use to create their shells and skeletons. Not only does acidification make it more difficult for these animals to make their shells, but it also can lead to the weakening or destruction of already formed shells

<u>Who is affected by ocean acidification? Who affects ocean acidification?</u>
Explain that they are going to become representatives from different groups that are either affected by ocean acidification in some way, or that contributes to ocean acidification in some way. They will take on the role of these 'stakeholders' and attend a mock conference aimed at trying to understand and solve the problem of ocean acidification.

Procedure: Day 1 (30 minutes)

1. Divide students into their stakeholders groups and give each their *Stakeholder Card.*
2. Give groups 20 minutes for small group discussion to prepare for the Mock Conference, knowing that they will be tasked with creating a poster that summarizes their stance.
   a. Allow students some time to read their *Stakeholder Card.*
   b. Remind them to take on the role of their stakeholder, even if that is not what they personally believe. Play up the role playing! Encourage them to have fun with their roles.
   c. Facilitate discussions among groups and help them manage their time.

   d. Have students create a draft of their poster on scratch paper.
3. Now, give students 10 minutes to create the final poster for the Mock Conference.
   a. Students must present their poster draft to a teacher before they can get poster paper and markers. This way you can monitor their progress and help them edit/revise their poster as needed. Encourage students to make their posters eye catching and easy to read.

Procedure: Day 2 (45 minutes)

1. Give groups 5 minutes to practice their 1-2 minute presentation for the Conference.
2. Spend 20 minutes on the **Mock Conference Presentations**: Six 1-2 minute presentations plus 1 minute for questions and transitions between groups.
3. **Mock Conference Discussion**/ Task Force Groups
   a. Break groups up into Task Force groups which include at least one student from each stakeholder groups. Remind everyone that they will still be playing the roles of their stakeholder.
   b. Give each Task Force an envelope prepared with one blank paper on the outside, and 5 on the inside.
   c. Each Task Force will come up with the *one biggest challenge* they all agree upon and write this on the *outside blank paper*, sending their envelope down the line to other Task Forces. When receiving an envelope, Task Forces will now focus on finding solutions to the challenges, writing solutions on a blank paper inside and returning this to the envelope before passing it along. In this way, at the end of the activity, each Task Force has received solutions from every other Task Force that they will share to the whole group. For step-by-step instructions:
      1. Give each of the Task Forces an envelope and ask the question: **What are the big issues or challenges surrounding ocean acidification?** Also give each group some scratch paper for brainstorming. You may need to adjust the number of pieces of scratch paper depending on the number of groups you have created. The number of pieces of paper is equal to *one less* than the number of groups you have, so if you have 6 groups you would give 5 pieces of paper.
      2. <u>Brainstorm challenges or issues (3 minutes)</u>: Each Task Force will brainstorm *on the back of their envelope* their ideas for the answer to the question. They will then circle or rewrite what their group feels is the biggest issue or challenge. *The issue they have chosen must be clear and legible so that other groups reading it will understand.
      3. <u>Pass envelope</u> to neighboring group: For example, all pass to the group on their left, or whatever works for the physical layout of your classroom.
      4. <u>Brainstorm solutions (2 minutes)</u>: Each Task Force now has a different envelope with another group's 'big issue'. On a piece of paper from the inside, brainstorm as many possible solutions to the 'big issue' as they can in 2 minutes.

5. Continue rotations (2 minutes each): At the end of 2 minutes, place their paper into the envelope and pass envelope to neighboring group. Each envelope will pass through each group once and end at the original group. This way, at the end of rotations, each Task Force will end up with the envelope with their 'big issue' and 5 other groups' papers with their solutions to that issue.
6. Choose the best solutions (5 minutes): each Task Force will have 5 minutes to review the solutions from the other groups and come up with their top 3 favorite solutions. To prepare to report back to the whole group, write each of the 3 solutions they picked on a piece of paper large enough to be able to see when posted on the wall or whiteboard. Students will report back during the Wrap-Up.

Wrap-Up: Day 2 (15 minutes)

- Bring the students back together and discuss with them their decision-making process.
- Divide your whiteboard or wall space into the following categories: Research and Development, Government Involvement and Regulation, Individual Level, and Other. Have each group share their 'big issue' and each of the 3 top solutions with the class. Then ask them to place each of their issues into the appropriate category.
    - **Research and Development:** any solutions that involve studying something to learn more. For example, one might study the effects of increased acidity on coral populations. Or, one might spend money on researching alternative energy to reduce reliance on coal burning energy plants.
    - **Government Involvement and Regulation:** any solutions that involve regulation of companies or groups. For example, one might suggest limiting the amount of carbon dioxide emissions a company can create or else pay a fine.
    - **Individual Level:** these are solutions that individuals can make, such as buy more energy efficient vehicles or appliances, or turning off appliances when they are not in use.
    - **Other:** other suggestions that don't fit into the above categories.
- Were they any commonalities in their issues or in their solutions?
- Highlight any of the solutions they came up with that are also currently being discussed in the real world. Refer to the Teacher Background section for a list of choices that are currently being discussed as of January, 2011.

Extensions

- Depending on the resources at your school, for the Conference Presentations, students can create a media-based presentation such as PowerPoint or video instead of a poster-based presentation.
- You may choose to have the Stakeholder Groups do their own background research to supplement the information on their *Stakeholder Cards.*

References

Maibach, Roser-Renouf, Leiserowitz (2009). *Global Warming's Six Americas 2009: An Audience Segmentation Analysis* http://environment.yale.edu/uploads/6Americas2009.pdf

National Resources Defense Council. *Ocean Acidification: The Other CO_2 Problem* http://www.nrdc.org/oceans/acidification

The Ocean in a High CO_2 World Symposium, Summary for Policymakers 2009 http://www.ocean-acidification.net/OAdocs/SPM-lorezv2.pdf

NOAA PMEL Carbon Program http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

Acid Test: The Global Challenge of Ocean Acidification
Film by the National Resources Defense Council, available online in its entirety http://www.nrdc.org/oceans/acidification/aboutthefilm.asp

US Energy Information Administration Annual Energy Review August 19, 2010 http://www.eia.gov/totalenergy/data/annual

Andiman, Martineau, Mink, Quiroz, *The Other CO_2 Problem: Chemical Reactions* http://theotherco2problem.wordpress.com/what-happens-chemically

Correlated California Content Standards

Grade Seven
Language Arts: Listening and Speaking
- 1.3 Respond to persuasive messages with questions, challenges, or affirmations.
- 1.5 Organize information to achieve particular purposes and to appeal to the background and interests of the audience.
- 2.4 Deliver persuasive presentations:
- a. State a clear position or perspective in support of an argument or proposal
- b. Describe the points in support of the argument and employ well-articulated evidence.

Grade Eight
Language Arts: Listening and Speaking
- 1.3 Organize information to achieve particular purposes by matching the message, vocabulary, voice modulation, expression, and tone to the audience and purpose.
- 1.8 Evaluate the credibility of a speaker (e.g., hidden agendas, slanted or biased material)
- 2.4c. Anticipate and answer listener concerns and counterarguments effectively through the inclusion and arrangement of details, reasons, examples, and other elements.

Biology (High School)
Ecology
- 6b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction on nonnative species, or changes in population size.

6f. Students know a vital part of an ecosystem is the stability of its producers and decomposers.

Earth Sciences (High School)
Acids and Bases
5d. Students know how to use the pH scale to characterize acid and base solutions.

Chemistry (High School)
Biochemical Cycles
7a. Students know the global carbon cycle: the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, fossil fuels, and the movement of carbon among these reservoirs.

Structure and Composition of the Atmosphere
8b. Students know how the composition of Earth's atmosphere has evolved over geologic time and know the effect of outgassing, the variations of carbon dioxide concentration, and the origin of atmospheric oxygen.

Science (High School)
Investigation and Experimentation
1l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
1m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings.

English-Language Arts: Grades Nine and Ten
Listening and Speaking
1.7 Use props, visual aids, graphs, and electronic media to enhance the appeal and accuracy of presentations.
2.5 Deliver persuasive arguments (including evaluation and analysis of problems and solutions and causes and effects):
a. Structure ideas and arguments in a coherent, logical fashion.
b. Use rhetorical devices to support assertions (e.g., by appeal to logic through reasoning; by appeal to emotion or ethical belief; by use of personal anecdote, case study, or analogy).
d. Anticipate and address the listener's concerns and counterarguments

English-Language Arts: Grades Eleven and Twelve
Listening and Speaking
2.4 Deliver multimedia presentations:
a. Combine text, images, and sound by incorporating information from a wide range of media, including films, newspapers, magazines, CD-ROMS, online information, television, videos, and electronic media-generated images
b. Use the selected media skillfully, editing appropriately and monitoring for quality.
d. Test the audience's response and revise the presentation accordingly.