Solving Local Environmental Challenges
Pacific Northwest Oysters, Shellfish Industry and Ocean Acidification

I. Background

Harvesting and production of shellfish in the United States is a multi-million dollar industry. On the west coast of the United States alone, shellfish farms represent over $200 million of the collective economies of California, Oregon, Washington and Alaska. The shellfish industry has been a productive and growing part of these state economies and the livelihood of its residents for many years. However, in 2006 things began to change for the shellfish industry. Shellfish growers throughout the west coast were witnessing declines in production, income, and the ability to provide shellfish for businesses and consumers. This story unfolds with one family company in Washington State called Taylor Shellfish Farms, who are major producer and distributor of oysters to many parts of the US and beyond.

Oyster growers at Taylor Shellfish farms, natural resource managers, and scientists worked together to identify the cause of these oyster die-offs and reduced production. After a few years of research and many false leads, they were able to identify ocean acidification as the culprit. As it turns out, oysters are like mussels and many other shellfish in that they make their shells out of calcium carbonate. Under normal conditions, oysters are able to generate new shell material quite easily. However, building shells is much more difficult when the pH of ocean water decreases. Young oyster larvae (called free-swimming veligers) are particularly vulnerable, especially during the 2-week period early in their lives when they begin to form a shell. During this time, low pH reduces their ability to make a shell and impairs their growth, health and survival well into their adult lives. For this reason, ocean acidification has potentially catastrophic effects on the oyster industry and those who depend on the harvest and sale of shellfish for their livelihood.

II. Building more Evidence: Additional local information on OA and the Shellfish Industry

You will now get some additional information on the impact of ocean acidification on the shellfish industry which can be used to start designing a solution to the challenges this poses for the shellfish industry.

1. Read the first page of the short NOAA article "Like putting headlights on a car" which describes some of the challenges faced by the shellfish industry and how ocean observing systems are involved in the solution.
   http://www.noaa.gov/features/01_economic/pacificoysters.html

2. Watch the first part of the PBS report titled "Ocean Acidification's impact on oysters and other shellfish". Pause the video at 3:20 after Bill Dewey of Taylor Shellfish describes the effect of ocean acidification on oyster larvae. (You will resume the video at the end of the activity).
   http://www.pmel.noaa.gov/co2/story/Ocean+Acidification's+impact+on+oysters+and+other+shellfish

OPTIONAL: Based on the content of the video, reading and prior content from the course, add to your "Cause and Effect" flowchart to describe the downstream effects of elevated CO_2 on ocean pH, oyster larvae, adult oysters, and the people who rely on the oyster industry for income and livelihood.

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III. Designing Solutions: How can the shellfish industry overcome the effect of OA on oyster larvae?
Imagine you are an oyster grower in the Pacific Northwest, with many families, employees, restaurants and seafood distributors that depend on you for oysters and livelihood. In order to maintain production of healthy oyster larvae, you need to pump fresh ocean water into your hatchery daily until they reach an size when they are less vulnerable to changing environmental conditions (approx. 2 weeks). However, if you pump ocean water into your hatchery that is too low in pH, millions of oyster larvae might die and shellfish growers will be left without oyster seed.

Work in small groups to come up with a strategy for overcoming some of these problems associated with ocean acidification. *For this activity, you will need to call on previous content and make new connections regarding daily and seasonal patterns in dissolved oxygen, CO2, and pH, and Data Activities: Comparing patterns in global, regional and local data.*

The following questions will help build evidence for possible solutions.

1. What do you know about the daily variability of oxygen and carbon dioxide? How is this related to pH? When is pH low during the day? When is it high? Can you use this to your advantage when collecting water to raise oysters?
2. What do you know about the seasonal fluctuation of ocean pH? Is this pattern predictable? Could this information help with timing the collection of water for growing oysters?
3. What technologies are available to monitor ocean chemistry and water quality? How would you use these?
4. Is there anything else you know about the seasonal fluctuation of ocean pH? Are you familiar with any other oceanographic processes bring low pH water to the surface? How could this information be helpful?

Write down your solution. Use drawings or illustrations to provide a more detailed description.

IV. Effects of ocean acidification in your local waters
What are some of the local, ocean-based industries in your area? Which of these might be impacted by ocean acidification? If not ocean acidification, are there other changes in the oceans related to pH, water quality or climate that would have an impact on these industries? (*Record your answers*)

V. Comparing Solutions
Read the second page of the NOAA article *Putting headlights on a car* and finish watching the PBS report on ocean acidification.

1) What are some of the solutions that oyster growers implemented to deal with low pH waters? Were these similar to your solutions?
2) What ocean observing technologies were used to assist in their solutions?
3) We have focused on oysters in the Pacific Northwest. What other coastal industries are potentially affected by ocean acidification? Were you surprised by these?
4) Share your proposed solutions for dealing with low pH ocean water with the rest of the class and compare your strategies.