Lesson Extensions

LESSON 1: CORAL, CARBON DIOXIDE AND CALCIFICATION

Extension A: Changes due to increased atmospheric carbon dioxide

Simulate a large amount of atmospheric carbon dioxide added to the system. You can introduce this as, **"we've simulated how part of this system might work… what would happen if we changed some of the inputs?"** Bring out a LARGE box of pieces (doesn't have to be full, only look like it). Let the chain work (steps A-E) until they are overloaded and stop.

Extension B: Increased temperature

Coral and other biological systems are stressed by increases in temperature. It is possible to raise temperature to certain point and have the system function, but then productivity stops and eventually the organism dies.

Dress *Coral* in a heavy winter coat and hat. Turn on a bright light. Start the process again. Make sure that *Coral* does a lot of movement. Increased temperature increases rate of reaction, so have the assembly line work faster and faster until they are hot, overloaded and stop.

Extension C: Adjust the complexity to suit your students

- Use colored blocks to represent the different components (*See Supplementary Background Information for Lesson 1*) or design your own code. Use the code for labels and instructions.
- Use only key chemical names - carbon dioxide, water, carbonic acid, etc. – with or without formulas.
- Use tags/lanyards to designate roles – "Coral", "Ocean", "Atmosphere" and "Dissolver." Include the Role Title and Job Summary.
- Brainstorm physical motions to represent the different parts/occurrences in the system (students can help with this). For example, the phrase "Reaction, reaction"– "jazz" hands; water – rippling wave motion with arms, *Coral* – back of wrist held to top of forehead, fingers opening and closing like a hydroid, one hand is free per student so they will need to work together to assemble blocks, etc.

LESSON 2: INQUIRY INTO OCEAN ACIDIFICATION

Extension A: Effects of acidification

Find online pictures of the effects of acidification on marine organisms and have students share these with the class

Extension B: Changes in pH over time

Humans have had a great impact on the world's oceans. Ask students to think about the ocean during the distant past (over geologic timescales). What conditions (other than humans) may have changed ocean pH? (*Answers will vary but may include volcanic eruptions increasing atmospheric carbon dioxide levels and the deposition of calcium-carbonate shells as a result of the Permian-Triassic extinction of many marine invertebrate species.)*

LESSON 3: OCEAN CURRENTS AND MARINE DEBRIS

Extension A: Deep currents

Create thermohaline circulation (use an aquarium for class demonstration). Fill the aquarium 3:1 salt water:fresh water. Add at least 4 tsp. salt per gallon of water (35 g salt per liter). Dissolve thoroughly. (The salt water should look slightly "fuzzy" or "shimmery.") Method 1: Add the bag of ice at one end and the heater at the other end of the aquarium. Method 2: Reserve one part of the saltwater. Chill. Add the rest of the saltwater to the tank. Carefully pour the freshwater down the side of the tank, to minimize mixing the water. Add the heater at the other end.

Finally, add drops of blue food color below the bag of ice (or area of chilled saltwater) and drops of red food color to the side of the heater.

Extension B: Watch and write about *Paddle-to-the-Sea* DVD

Creative writing prompts:

- If you were Paddle-to-the-Sea (or a Nike shoe, a rubber toy, etc.)… follow the waters in your watershed. Would you end up in the sea? What would you encounter?
- Pretend you are a plastic bottle thrown overboard by a careless boater. Where did you enter the ocean? Where did the currents take you? What did you encounter? What ultimately happened to you?

Encourage students to include scientific detail: where did the currents take you? Where in the water column did you travel: at the surface or in deep currents? What did you encounter (animals, plants, temperatures, light/dark, etc.)? What ultimately happened to you? (recycled, swallowed by a sea bird, joined the mass of trash islands, covered in algae, etc.)

Extension C: Discuss local connections

- What kind of non-trash marine debris items (Nike shoes, plastic bath toys, glass floats, etc.) have been found in your area? Interview adults or search the internet for information.
- What can people in your area do to prevent marine debris?

LESSON 4: AEROSOLS AND CLOUDS

Extension A: Vary the concentration of particles

Use more than one match, a larger or smaller scoop of chalk, ash or salt. Have students help determine variables.

Extension B: Vary the temperature of the water

Use ice water to simulate clouds forming over polar oceans.

Extension C: How do aerosols vary daily, among locations, globally?

Use with "Aerosol Lab Activity" – (Trap and Count Local Aerosol Particles) http://asd-www.larc.nasa.gov/SOLAR/labactivity-index.html

Extension D: Collect your own cloud observations for NASA

The crew of *Ocean Watch* collects cloud coverage data for NASA, and you can do the same from your school or backyard! Instructions and an online tutorial are here: http://science-edu.larc.nasa.gov/SCOOL/index.php

LESSON 5: SNAPPING SHRIMP

Extension A: Add additional roles

- *Detector/Researcher* (as many as desired) – sits with their back to the ocean. Has a checklist of possible sounds and records their identity/path. After scenario, checks data with Observers.
- *Observer* - Observes the scenario and records identity/path of sounds. Provides feedback to Detector/Researchers.
- *Goby* – pair some of the shrimp with a Goby friend. The shrimp should squint – enough to partially obscure vision, but not enough that shrimp without a Goby will get injured. The Goby watches and alerts the shrimp to predators and competitors. Who was more active – the solo shrimp or the Goby-shrimp pairs?

Extension B: Locations of snapping shrimp

Locate areas on a map or globe where you think researchers on *Ocean Watch* will find snapping shrimp.

Extension A: Catch-share simulation

Each group designates one person as the Fish Regulator – the person setting the quotas. This person does not fish. The quota, or amount of fish that can be taken, is decided for the season. The Fish Regulator can take advice from others, but s/he determines the total of fish that can be taken, while leaving some fish in ocean so they will reproduce and replenish the fish stocks.

Every fisher in the group is allotted a share of the total quota.

Have fishers fish several seasons and reflect on process before you discuss the details of real catch share programs.

Reflection:

- What did you notice about the behavior of individuals in each season? (Individuals were not in as much of a hurry. There wasn't as much competitive behavior. There wasn't a rush. People took turns. People worked cooperatively.)
- How does these fishing seasons compare with the previous (non-quota) fishing seasons?
- How do the number of fish caught vs. remaining at the end of the season(s) compare? (When there wasn't a quota, people took as many fish as they could get, until the fish were gone. When there was a quota, people had to stop fishing, but there were more fish in the ocean for later years.)

Variations to Extension A – Economic Effects

A. Fish shares can be bid on and "bought" at auction and/or traded among fishers.

- How does this change the scenario?

B. "Fish" tokens can be "sold" or traded in for "money."

Students will need to "sell" their fish at the market (at a location away from their ocean, such as the front of the classroom). Fishers can bring their fish to market at any time. (A large crowd of students waiting to "sell" their fish will illustrate when the market is "flooded.")

Vary the price (exchange rate) for the "fish" according to supply and demand – a large number of the same type of fish on the market will drive down the price-per-fish. Price ranges should suit the mathematical level(s) of your students.

Extension B: Do you know what fish you're eating?

Present the following Research/Reflection questions in class. Give students an opportunity to wonder and form their own questions on this topic. After they have completed their research, have them share their results, opinions and reasons.

Research Questions and Reflection:

- What type of fish do you eat?
- What types of fish are at the local stores and restaurants?
- Where do they come from? Oceans or rivers/lakes? Local or distant? Wild or Farmed?
- Are these fish available all year or only during certain times?
- What is the abundance of these fish? Are they over-fished?
- Based on your research, which fish would you choose to eat? How did your research influence your choice(s)?

Recommended Research Resources:

Blue Ocean Institute Seafood Guide:
"Blue Ocean Institute Seafood Guide." Blue Ocean Institute. 06 Mar. 2009 <http://www.blueocean.org/seafood/seafood/seafood-guide>.

Seafood Watch Card:
Download a Regional Seafood Watch Card, Monterey Bay Aquarium, California. 06 Mar. 2009 <http://www.montereybayaquarium.org/cr/cr_seafoodwatch/download.aspx>.

FAO Fisheries Distribution Maps:
"FAO Fisheries & Aquaculture Compilation of Aquatic Species Distribution Maps of Interest to Fisheries, Overview." Fishery Statistical Collections. Food and Agriculture Organization of the United Nations. 07 Mar. 2009 <http://www.fao.org/fishery/collection/fish_dist_map/en>.

Extension C: Local fishers

Explore the history, technology and cultural importance of fishing methods of various local commercial, recreational, subsistence and artisanal (traditional/tribal) fishing groups through guest speakers, fieldtrips, interviews and recordings (Marine Stewardship Council 2008).

- How does this fishing method work?
- If they could add a new or different fishing method/technology, what would it be?
- How did they start fishing? Are other family members fishers?
- What do they think would surprise most people about fishers or the fishing process?
- What do they enjoy the most/least about fishing?
- What is their favorite type of fish? Why?