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Bringing critical systems thinking to high school students through ocean acidification research

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Bringing critical systems thinking to high school students through ocean acidification research


5/1/2014 Salish Sea Conference – Novel Actions to Address OA in the Salish Sea
Our 4th module – Ocean Acidification: A Systems Approach to a Global Problem

- Model current interdisciplinary research and connect to the work of others.
- Teach the process of thinking.
- Students as scientists and delegates.
- 3-5 weeks of class time.

Photos: genome.jgi-psf.org/Thaps3, www.pnas.org/content/105/5/1391/F1.expansion.html
Main Goal

Analyze the effect CO₂ has on ocean chemistry, ecosystems and human societies

Classroom exercise: analyzing a social network

1. In an interactive group activity, students use familiar cell phone networks to learn about how information can be easily depicted.

2. Students pull together the class information to quickly learn that even when working in a team of five, it is still difficult to organize and analyze all of the information.
Motivation to use tools to solve problems
Systems thinking enables behavioral changes

Poster: Waters Foundation
Lesson 1 (Introduction through case studies): Understand the broad reach and accessibility of ocean studies and gain the critical thinking skills to properly evaluate news media.
Lesson 2: Exploring CO$_2$ in the lab

A. Use inquiry to understand CO$_2$.
B. Learn the basics of the changing carbon cycle and ocean acidification.
Lesson 3

• Watch Acid Test video – realize this is a global problem with many stakeholders
• Setting the stage to model a collaborative lab group
• Is this a situation that requires a systems study?
  – Many parts with interactions, emergent properties, reverberating effects?
Does this require a systems study?

- Trees and Plants (photosynthesis)
- Animals (respiration)
- Marine Organisms (respiration)
- Phytoplankton (photosynthesis)
- Combustion Reactions
- ?
Lesson 4-5: Exploration of the effects of changing nutrient and carbon cycles

- In interest groups, experiment, analyze public (online) data, and prepare for a mock summit to address concerns.

- **Main question:** What effect does the increasing atmospheric CO$_2$ have on the ocean and its subsystems?
  - Model collaborative research by completing a cohesive set of experiments in order to determine the correct interactions within their sub-networks
  - Emphasis on need for multiple and diverse data
  - Need for multiple stressors
Options

A. Student interest groups each design their own experiment

B. ~ 8 protocols available for student groups to complete – slight variations

• Diatoms – various nutrient, CO$_2$ entry, water, temperature, salinity types

• Shell and bone dissolution with sea urchin online lab

• Physical chemistry experiments
Growth curves as determined from hemocytometer counts performed by ISB high school interns
Need for multiple & diverse data

- Daily culture measurements:
  - Cell count using a hemocytometer
  - OD 600 reading/Fluorometer reading (depending on what technology is available)
  - Pigment description
  - Pigment extraction experiment
    - Chromatography

Example of experiment design

5g of dry ice were used to stabilize CO₂ levels at approximately 2000 ppm. pH of seawater dropped from 8.0 to 6.5 overnight. Shells left in seawater lost 2% of their mass over 3 days.
Supplement their experiment with online data component.

- Bad Acid: Sea Urchin Simulation
- C-MORE
- WA State Department of Ecology (Eyes over Puget Sound)
- Multiple in situ sensors
- Ice Core studies
- Mesocosm studies
- Many NOAA resources
- Carbon footprint calculators
NetLogo / Java simulation for generating hypotheses.
Lesson 6: Mock Summit

Students as scientists and delegates
Discuss findings and next steps for all parts of the system

• Emphasis placed on the impact on the subsystem and system.

• Students reflect on unanswered questions, next steps and on what their roles
  – How they might change their actions in order to impact the network?
  – What does their final, class experimental network look like?
Atmospheric CO2 Level

CO2 Polluting Nations

Developing Island Nation Economies

Ocean

CO2 Absorbed by Ocean

Nutrients

Oxygen

Diatoms

Carbonic Acid

Calcium Carbonate

Marine Calcifying Organisms

Ecosystem Services

Reef Tourism

Fisheries

Higher Trophic Level Fish Dependent on Marine Calcifiers
Atmospheric CO2 Level

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Fish Dependent on Marine Calcifiers

Higher Trophic Level Fish Dependent on Marine Calcifiers

Nutrients

Marine Calcifying Organisms

CO2 Absorbed by Ocean
Is it working?

• Yes! They’re learning, engaged, and thinking - systemically and locally.

Where are we going next?

• Genetic component, with predictions of future responses, acclimation and adaptation

Thank you for listening – please visit me for more information.

http://staff.wwu.edu/stefan/salish_sea.shtml
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