The WAR for Carbonate Ions in Ocean Acidification

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Summary

This short activity allows students to visualize the negative impacts on ocean organisms as the pH of the ocean drops (ocean acidification or OA). It focuses on the how the changes in ocean chemistry, as more CO2 dissolves in the water, affects life in the ocean. Student groups play four rounds of a modified card game *War* with the changes in the rules as the pH of the ocean drops. This activity will help uncover student misconceptions that in order for OA to hurt organisms, the pH must reach acidic levels. This lesson is part of a broader unit on pH which would be applicable to both chemistry courses and the biochemistry unit in biology as well as ecological impacts of a changing environment.

*TAGS: Ocean Acidification, pH*

Key Concepts

Lowering of the pH of the ocean (increasing acidity) will have a negative impact on marine organisms

Objectives

Include clear, measurable statements of what students will be able to do, such as:

* Ask questions and construct explanations
* Define problems and design solutions
* Develop and use models
* Plan and carry out investigations
* Analyze and interpret data
* Use mathematics and computational thinking
* Engage in argument from evidence
* Obtain, evaluate, and communicate information

Materials

* Teacher materials
	+ Link to Background Information (will be coming…really)
	+ Internet access to show video
	+ Possible answers to Student trends for Student Data, Observation and Trend Sheet
* Student materials
	+ Deck of cards (deck of cards per 2 students)
	+ Student Data, Observation and Trend sheet

Procedure

1. Students should have a basic understanding of the pH scale. Teachers should lead the class in a brief overview of the dissociation of carbonate ions when in the ocean. The more CO2 dissolved in the water, the more carbonic acid produced which can lose a H+ to bicarbonate ions and carbonate ions that are produced which increases the acidity of the water (lowers the pH)



1. Put students in groups of at least two and provide the appropriate decks of cards.
2. WAR rules to the game. The childhood card game is very simple, a deck of cards is shuffled and then dealt out to each player until the deck is empty. On “GO” players take their top card and turn it over. The high card wins all the other cards (a two is the lowest card and ace is the highest card).
3. Students will pick and organism (possible choices: pteropod, sea urchin, Dungeness crab, coccolithophore, oyster, fish (like a clownfish, salmon).
4. The set up for each round is as follows below:

**pH of 8.2**, shuffle and randomly deal the cards so that each player has the same number

**pH of 8.1**, first give 2 aces, 2 kings, 2 queens, 1 jack to the ocean player (this is for one deck of cards, if there are two decks, multiply X2, three decks X3 etc), shuffle and then randomly deal the rest of the cards to that each player has the same number.

**pH of 7.9** Two aces, two K, two Q and 2 Jacks are taken out of the deck before random dealing the rest (18 more cards to the ocean and 26 to the organism)

**pH of 7.8** 4 aces, 3 K, 3 Q and 3 Jacks are taken out of the deck before random dealing the rest (13 more cards to the ocean and 26 to the organism)

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|  | OCEAN student deck | pteropod | Sea urchin | Dungeness crab | Salmon (or clownfish) |
| **pH of ocean** | No matter how many players are in the game, all players should have the same number of cards |
| Current (8.2) |  random dealing |
| 8.1 (26% change from 8.2 \*) | Two aces, two K, two Q and 1 Jack are taken out of the deck before random dealing the rest (19 more cards to the ocean and 26 to the organism) | Multiple X2 | Multiply X3 | Multiply X4 | Multiply X5 |
| 8.0 (32%\*) 58% | Two aces, two K, two Q and 2 Jacks are taken out of the deck before random dealing the rest (18 more cards to the ocean and 26 to the organism) |  |  |  |  |
| 7.9 (42%\*) | 3 aces, 3 K, two Q and 2 Jacks are taken out of the deck before random dealing the rest (18 more cards to the ocean and 26 to the organism) |  |  |  |  |
| 7.8 (51%) | 4 aces, 3 K, 3 Q and 3 Jacks are taken out of the deck before random dealing the rest (13 more cards to the ocean and 26 to the organism) |  |  |  |  |

\*based on data from [https://pmel.noaa.gov/co2/file/Percent+change+in+acidity](https://pmel.noaa.gov/co2/file/Percent%2Bchange%2Bin%2Bacidity)

6. Play the game. After all the cards have been flipped over. Have each player record on the student sheet how their total card count. All but the ocean player will also record how they fared with the necessary functions based on the chart below. For example if a player has 12 cards, she would stay alive and have avoided being eaten by a predator. If a player had 23 cards, he would have stayed alive, avoided predators, been able to grow/molt/lay down a shell, reproduced and still have some left over energy (need to explain in the background section how lowering the pH affects all of these functions).

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|  | # of cards needed to perform the function(does not matter what the cards number is, an ace and a 2, both would count as 1 card) |
| Activity | 52 card deck | 2 decks | 3 decks | 4 decks | 5 decks |
| Stay alive (includes cellular respiration) | 5 cards |
| Avoid a predator | 5 cards |
| Grow (molting, laying down shell, etc)  | 5 cards |
| Reproduce (Produce gametes like eggs/sperm) | 5 cards |
|  | Extra cards means that the critter has some extra energy for other activities (don’t need to use the energy to maintain homeostasis, etc) |

1. Set up Round 2 of the game (stacked in the ocean’s favor), play WAR and record.
2. Do the same for Rounds 3 and 4
3. Have student groups discuss the trends that they are seeing with

Assessment

* **Formative assessments**—class discussion (develop class questions)
* **Summative assessments**—provide student groups or individuals, a written prompt that includes a scenario for one organism in the ocean and how it would react to a change in the ocean’s pH (develop three sample prompts and provide rubric for anwers)

Additional Resources

* <https://www.whoi.edu/oceanus/feature/small-drop-in-ph-means-big-change-in-acidity> (nice article with concrete examples to relate pH changes).
* [https://pmel.noaa.gov/co2/story/A+primer+on+pH](https://pmel.noaa.gov/co2/story/A%2Bprimer%2Bon%2BpH) (very rich source with lots of links)
* 12 minute video <https://www.youtube.com/watch?v=GL7qJYKzcsk>

Extensions or adaptations

1. Students can calculate the percentage change from each 0.1 decrease on the pH scale.

2. Students can calculate the number of cards that need to be added to the Ocean Deck with each change in pH.

3. Students can research their chosen organism and make a slide, flyer, short video, etc to teach the rest of the class on how lowering the pH may affect the organism (algae and seagrasses could also be added as choices). Students may present their findings to the rest of the class or hang them on the wall for other classes to enjoy.