360Storylines: Ocean Acidification

Lab 1: The pH of Seawater

IP: How does carbon dioxide change ocean pH? Write a possible explanation of this phenomenon.	**AP:** What effect does a decreasing ocean pH have on the plants and animals that live there? Based on what you learned in this experiment, try to formulate an explanation to answer this question. What evidence did this experiment supply to aid in your understanding?
Students generally understand that greenhouse gases are bad for the environment, but it is hard for them to see all the details. They should know that carbon dioxide is bad for the environment. At this point students will likely only be able to say that the ocean absorbs the carbon dioxide, changing its pH. But they may not be able to provide further explanation.	At[1] this point students should understand that most plants and animals have a specific pH range they safely live in. If the ocean pH becomes more acidic, the more dangerous it becomes for the marine life. Coral bleaching is a prime example.
Revised Explanation: After performing the experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation.	
This lab should really help students understand that carbon dioxide and water react to form carbonic acid. They should conclude that as the ocean absorbs more carbon dioxide, the concentration of carbonic acid increases and the ocean pH decreases.	

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Lab 2: Carbon Dioxide Levels in Water

IP: How does climate change affect the concentration of greenhouse gases? Write a possible explanation of this phenomenon.	**AP:** In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of ocean acidification?
Students know that greenhouse gases are a direct factor in climate change. What can be difficult to understand is that it is a feedback process. Most students will conclude that as climate change continues, the concentration of greenhouse gases will increase.	Students will still be focused on pH at this point. As the ocean pH continues to drop, the environment will become more and more toxic to the plants and animals living there. Coral bleaching affects every plant and animal that relies on it for food and shelter. This will in turn affect the animals that feed on coral reef plants.
Revised Explanation: After performing the lab experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–2 to formulate an explanation of the effect of ocean acidification on the marine environment.
This lab should give students a better idea of how rising temperatures play a role in greenhouse gas concentration. A higher temperature causes the release of more CO_2 gas that is trapped in the ocean. Then there is an increase in the concentration of CO_2 gas in the atmosphere. This can be absorbed by the ocean again.	Carbon dioxide is a very dangerous greenhouse gas that can be catastrophic for marine life at high concentrations. Students should hopefully understand, though, that not all CO_2 is bad. The ocean does need it. The students should focus their answer on the cascading effect of damage that can be caused by high concentrations of CO_2.

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Lab 3: Ocean Currents

IP: What effect do melting glaciers have on ocean currents? Write a possible explanation of this phenomenon.	**AP:** Does fresh water have a different pH than salt water? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of ocean acidification?
It's not just about oceans having more sodium chloride than fresh water. This will be hard for them to understand. Most answers will revolve around the water level rising and increasing the strength of the currents.	Salt water contains more sodium chloride than fresh water. This means that oceans typically have a more basic pH. The pH of fresh water is generally neutral but can vary depending on location. As fresh water glaciers melt they decrease the pH of the ocean.
Revised Explanation: After performing the lab experiment, what revisions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–3 to formulate an explanation of the effects of ocean acidification on the marine environment.
Students should now recognize that how salt water and fresh water mix is directly related to their density. Fresh water is less dense than the ocean water. Students should also incorporate temperature in their answer. The colder water mixes faster so as glaciers melt the mixing is more rapid creating more current which further mixes the two.	Carbon dioxide absorption is not the only factor in ocean acidification. Glaciers are made of fresh water and as they melt they are mixing into the salt water of the ocean. Since the pH of fresh was is more neutral it is slowly moving the ocean pH away from the basic region. What students should understand here is that while this is a slow process for humans, on a geological time scale it is happening rapidly.

Lab 4: The Fate of Carbonate in Acidifying Oceans

IP: How is the carbonate equilibrium affected by pH? Write a possible explanation of this phenomenon.	**AP:** What are the long-term effects of calcium carbonate depletion? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of ocean acidification?
This is where students really dive into the specific relationship of carbon dioxide and ocean pH. Students should be able to relate the carbon dioxide absorption by oceans to the formation of carbonate and carbonic acid. They may struggle with relating equilibrium with pH at this point.	Calcium carbonate is an extremely important component used in shell production. Many organisms rely on this in the solid form to generate their shells. The depletion of this mineral in the solid form occurs slowly, but as the effects of climate change continue, the lack of calcium carbonate will decimate shell producing marine life.
Revised Explanation: After performing the lab experiment, what revisions or additions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Working Model:** Apply what you have learned in labs 1–4 to formulate an explanation of the effects of ocean acidification on the marine environment.
Students should now understand how equilibrium can be affected by changes in pH. Carbon dioxide is not the only factor in ocean acidification. As the ocean pH decreases, the carbonate equilibrium shifts to favor aqueous carbonate. What students might miss is that this also produces more carbon dioxide gas, which as temperatures rise, is released into the atmosphere.	Carbon dioxide continues to be the focus of ocean acidification. Calcium carbonate is generally pretty insoluble, leaving plenty of solid available for calcifying organisms. As the ocean pH decreases, the carbonate equilibrium will favor the soluble form of carbonate. This means there is less available for shell production. The marine life that uses those organisms as a food source will die off, and the cascade will continue as each level of the food chain is affected.

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Lab 5: Calcium Carbonate and Shell Production

IP: How does ocean pH affect calcifying organisms? Write a possible explanation of this phenomenon.	**AP:** Can the effects of ocean acidification on coral reefs be reversed? In what way(s) do you think this lab experiment relates back to the anchoring phenomenon? How does the evidence collected in this experiment add to your understanding of ocean acidification?
As this is the last lab in this series, students should have a pretty clear answer to this question. As ocean pH drops, less solid calcium carbonate is available for shells, and their population will decrease.	This is a complicated question for students to answer because there is not one specific answer. Hopefully they conclude that it depends on the extent of the damage and whether or not the issue is being addressed. In some instances, the damage may be reversible, but in other cases the coral reef bleaching is too extensive.
Revised Explanation: After performing the lab experiment, what revisions or additions need to be made to your explanation of the ***IP***? What observations did you make that led to these revisions? Write your new explanation below.	**Final Model:** Apply what you have learned in labs 1–5 to formulate an explanation of the effects of ocean acidification on the marine environment.
Ocean acidification is a slow process from a human perspective. This lab will help students see how an increase in acid concentration affects solid calcium carbonate. On a geological time scale this is happening quite rapidly.	Carbon dioxide absorption decreases the ocean pH. Most plants and animals have a specific pH range they require to live. A more acidic environment also depletes the amount of solid calcium carbonate available for shell producing organisms. The coral can't provide protection and food, organisms can't grow shells, and animals that feed on those organisms have now lost their food source. Students should hopefully see how devastating this cascade can be if it is not stopped.