# Acidic Seas Educator Guide

A resource for using QUEST audio in the classroom

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## QUEST SUBJECTS

**Life Science**: **Biology**, Health, **Environment**

**Earth Science**: Geology, **Weather**, Astronomy

**Physical Science**: Physics, **Chemistry**, Engineering

## CA SCIENCE STANDARDS

**Grade 6**

*Ecology*
5. (e) the organisms an ecosystem can support depends on the resources available and on abiotic factors.

**Grade 8**

*Reactions*
5. (a) reactant atoms and molecules interact to form products with different chemical properties.

*Chemistry of Living Systems*
6. (a) carbon has a central role in the chemistry of living organisms.

**Grades 9-12**

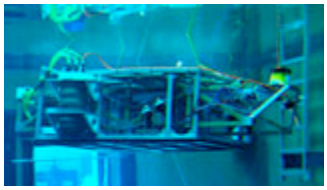
*Ecology*
6. (b) analyzing changes in an ecosystem resulting from changes in climate, population, human activity or introduction of nonnative species

*Earth Sciences*
*Energy in the Earth System*
6. (c) climate change over time

## PROGRAM NOTES

For years, our oceans have been hard at work absorbing the carbon dioxide that humans create through burning fossil fuels. But all that extra $CO_2$ is having a dramatic effect. It's making our oceans more acidic.

In this segment you'll find…



- what scientists have learned about ocean chemistry.
- how ocean acidification affects marine animals, food webs and ecosystems.
- possible outcomes of continued ocean acidification.

## TOPIC BACKGROUND

For centuries, the ocean has absorbed carbon dioxide from the atmosphere and vented it out again in a steady, cyclical process. In the natural carbon cycle, $CO_2$ is primarily absorbed through two avenues: photosynthesis by phytoplankton and through a simple chemical reaction as carbon dioxide dissolves in the seawater. When carbon dioxide from the atmosphere dissolves in the ocean, it creates bicarbonate, carbonate and carbonic acid. A form of carbon, bicarbonate doesn't escape the water easily, so small amounts of carbon remain trapped in the ocean. However, for most of history the amount of carbon concentrated in our atmosphere remained relatively stable, so the absorption rate of carbon into the ocean remained in balance.

With the coming of industrialization in the 1800s, people and their machines began pumping more $CO_2$ and other greenhouse gases into the atmosphere. As we burned more and more fossil fuels, the atmospheric carbon dioxide levels continued to increase. By 2006, these levels were about 30 percent higher than they had been just a few hundred years ago, and scientists predicted that this number would double or possibly even triple by the end of the 21st century. With such an increase in atmospheric carbon dioxide levels, the ocean began absorbing more carbon dioxide to stay in balance with the atmosphere. This increase in carbon absorption lowers the pH of the seawater, making the ocean more acidic and changing the balance of the carbonate and bicarbonate being produced. Today the ocean absorbs about one-third of all human-released $CO_2$. The acidic shift in the sea lowers the concentration of carbonate being filtered into the water, making it more difficult for some marine species to survive, particularly corals and other species that need calcium carbonate to build their shells. Biologists worry that the implications of this shift could prove devastating, since several heavily affected species, such as a small marine snail called a pteropod and an amoeba-like organism called foraminifera, are a major food source for fish and some marine mammals, including some whales. Scientists are also concerned about the effects of acidification on some corals, effects that might include bleaching and/or disintegration of the coral itself.

## VOCABULARY

**Atmosphere**
The mass of air surrounding Earth

**Brachiopod**
A small phylum of marine invertebrates also known as lampshades

**Emissions**
Substances discharged into the air

**Carbonic acid**
A weak acid that reacts with bases to form carbonate

**Acidity**
The state, quality or degree of being acid

**Calcium carbonate**
A chemical compound that serves as the main component of shells of marine organisms, snails and eggshells

**Food web**
Interrelated food chains in an ecosystem

**Carbon dioxide**
A colorless, odorless and tasteless gas

**Organism**
An individual plant, animal, fungus or other form of life

## PRE VIEWING

- What do you already know about the ocean and marine life?
- How does the burning of fossil fuels affect Earth?
- What is the difference between an acidic solution and a basic solution? What is pH?

## VIEWING FOCUS

NOTE: You may choose to watch the radio slideshow twice with your students: once to elicit emotional responses and get an overview of the topic and again to focus on facts and draw out opinions.

- How has ocean acidity changed over time?
- What is causing ocean acidification?
- What kinds of marine life are negatively affected by an increase in ocean acidity levels? How are they affected?
- What do you think can be done to change the pH levels in our oceans? Should we implement such changes?

*For all media see:*
- Segment Summary Student Sheet
  http://www.kqed.org/quest/downloads/QUEST_SegSum_StudentSheet.pdf
- Personal Response Student Sheet
  http://www.kqed.org/quest/downloads/QUEST_PersResp_StudentSheet.pdf

## QUEST, PBS and NPR LESSON PLANS and RESOURCES

NOTE: Resources from the Teachers' Domain collection require a fast and free registration.

**Global Warming** Teachers' Domain
http://www.teachersdomain.org/resource/tdc02.sci.life.eco.lp_co2globalwarm/
In this lesson on global warming and greenhouse gas production, students analyze how much carbon dioxide they use in one day.

**Acid Lake** Teachers' Domain
http://www.teachersdomain.org/resource/lsps07.sci.life.oate.acidlake/
What happens when the pH of an aquatic ecosystem is changed? This interactive activity explains the pH scale and shows the effects of acid rain on a freshwater aquatic system.

**Is the Planet's Carbon Sink Getting Too Full?** NPR
http://www.npr.org/templates/story/story.php?storyId=12431939
This article discusses the important role the ocean plays in keeping Earth habitable. It examines why oceanic temperature is important to humans, despite the fact that we live on land.

**As Oceans Grow More Acidic, a Tiny Plant Thrives** NPR
http://www.npr.org/templates/story/story.php?storyId=89750336
Is ocean acidification destroying all marine life? Listen to a **Morning Edition** story about a special type of plankton that actually likes the increased acidity in our oceans.

**Predicting the Future of Reefs in Peril** NPR
http://www.npr.org/templates/story/story.php?storyId=17243164
How are coral reefs impacted by ocean acidification? This **Talk of the Nation** radio episode discusses three possible fates for coral reefs around the world as higher $CO_2$ levels begin to invade our oceans.

## VISIT OUR PARTNERS

**The Bay Institute**
www.bay.org

**California Academy of Sciences**
www.calacademy.org

**Chabot Space and Science Center**
www.chabotspace.org

**East Bay Regional Park District**
www.ebparks.org

**Exploratorium**
www.exploratorium.edu

**Girl Scouts of Northern California**
www.girlscoutsnorcal.org

**Golden Gate National Parks Conservancy**
www.parksconservancy.org

**The J. David Gladstone Institutes**
www.gladstone.ucsf.edu

**Lawrence Berkeley National Laboratory**
www.lbl.gov

**Lawrence Hall of Science**
www.lawrencehallofscience.org

**Monterey Bay Aquarium**
www.mbayaq.org

**Monterey Bay Aquarium Research Institute**
www.mbari.org

**Oakland Zoo**
www.oaklandzoo.org

**The Tech Museum of Innovation**
www.thetech.org

**UC Berkeley Natural History Museums**
http://bnhm.berkeley.edu/

**U.S. Geological Survey**
www.usgs.gov

## MORE EDUCATIONAL RESOURCES FOR USING QUEST MULTIMEDIA TO ENHANCE 21st CENTURY SKILLS IN TEACHING AND LEARNING

**Why Use Multimedia in Science Education?**
http://www.kqed.org/quest/downloads/QUESTWhyMedia.pdf
- Read about the importance of using multimedia in the 21st century science classroom.

**How to Use Science Media for Teaching and Learning**
http://www.kqed.org/quest/downloads/QUESTMediaTips.pdf
- A collection of tips, activities and handouts to actively engage students with multimedia.

**Science Multimedia Analysis**
http://www.kqed.org/quest/downloads/QUESTMediaAnalysis.pdf
- Give your students the tools to recognize the purposes and messages of science multimedia.

**Create Online Science Hikes with Google Maps**
http://www.kqed.org/quest/files/download/52/QUEST_ExplorationCreation.pdf
- Do you like the science hike Explorations on the QUEST site? Use this place-based educational guide to create similar science-based maps with youth.

## OTHER WAYS TO PARTICIPATE IN QUEST

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**Mondays at 6:30am and 8:30am**

**WATCH**

**KQED Channel 9**
**Tuesdays at 7:30pm**

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**ACIDIC SEAS QUEST RADIO TRANSCRIPT** | **NOTES/QUESTIONS**

When it comes to climate change, scientist Jim Barry says the atmosphere plays an important role. But it's not as important as the ocean.

BARRY: The oceans are the key pivotal part of climate change. Although we put this $CO_2$ up into the atmosphere, most of it is in the ocean already.

Barry says the ocean has been doing us a big favor. It's been sucking up carbon dioxide that humans add to the atmosphere from burning fossil fuels. All that $CO_2$ is having a dramatic effect. It's making the ocean more acidic.

BARRY: We're worried about how far we can change ocean pH and how that's going to affect the physiological function of a variety of animals from the base of the food chain all the way up to things like tuna and fishes we depend upon.

Barry opens the door to a walk-in freezer at the Monterey Bay Aquarium Research Institute, or MBARI, in Moss Landing. He reaches into a water-filled tank and pulls out a creature that looks like a small clam - called a brachiopod.

BARRY: There's a couple juveniles right there. These animals live at about 450-500 feet deep.

At that depth, it's about 47 degrees Fahrenheit. Barry will be watching how these deep-sea animals grow over the next few months, under very controlled conditions. A third of them will live in normal sea water.

BARRY: I'll immerse another third of them in tanks that have regular oxygen levels, but high $CO_2$ levels. And a third group is going to receive even higher $CO_2$ levels.

The experiment simulates what ocean chemistry will look like over the next hundred years if $CO_2$ emissions continue to grow. When $CO_2$ dissolves in water, it creates something called carbonic acid. It's the substance that makes a can of Coke bubbly, but it also makes ocean water more acidic. That may actually benefit some animals, but it could be disastrous for others, like animals with shells. More $CO_2$ means the ocean will have less of something called carbonate.

BARRY: Shells of most marine animals, clams, lobsters, corals – those are calcium carbonate. And when there's less carbonate ions around, it makes more difficult to create carbonate shells.

That could hurt the already-stressed coral reef systems of the world. Reefs are home to a million marine species and a recent study found that 30% of them are in danger of extinction. Other important animals could also be threatened, like tiny marine snails called pteropods -- a favorite food of young salmon.

BARRY: What I am concerned with, and many ocean scientists are, is how will these changes translate into changes in food webs.

To study this, MBARI scientists are engineering an experimental chamber that will study acidification on the ocean floor. That's what a group of them are working on just off the Monterey coast on the100-foot Point Lobos research vessel.

**ACIDIC SEAS QUEST RADIO TRANSCRIPT** **NOTES/QUESTIONS**

For the equipment's first test, the team is sending it to the ocean floor on the Ventana, a remotely-operated unmanned vehicle. They launch it off the side of the ship and follow the mission from a control room on deck.

COMM: Ok, ok we're gonna launch. OK, ready up here. Hydraulics coming up.

As it drifts downward, the vehicle is plunged into darkness.

COMM: Am I on zero, dj? Thrust? 120. Ok I'm going to thrust it down. 240. Ok what am I now?

Half an hour later, it touches down at 1300 feet - and the test run begins.

COMM: Okee, dokey. Nice job, Greg. Man, way to go Greg.

It's easier to get a look at the device back at MBARI headquarters. It's a large Plexiglas container with wires and tanks attached to the sides. Right now the chamber is suspended in a 30-foot deep indoor pool by an overhead crane.

Peter Brewer is the senior scientist in charge of the project. He's been tracking ocean chemistry for more than three decades.

BREWER: It's a large rectangular frame with a propeller at one end, which turns slowly and moves the water.

And into that water we'll put tiny amounts of carbon dioxide.

Chambers like this one will be used on coral reefs and the sea floor. Scientists will control the water chemistry inside to see how marine organisms react. Brewer says biologists are racing against the clock.

BREWER: There are layers of complexity as we're changing our world which are only dimly understood at the moment. We are disposing of carbon dioxide in the ocean, via the atmosphere, at about a million tons an hour.
Make no mistake, these are big changes.

Brewer says the surface waters of the oceans have become 30% more acidic in the last 200 years. That rate of change is accelerating rapidly. Scientists expect waters to be twice as acidic by the end of the century. A study released in June found that more acidic water is already appearing off the Pacific Coast, sooner than expected.

For QUEST, I'm Lauren Sommer, KQED Radio News.