A joint collaborative project of:
Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration
Ocean Acidification Program
National Oceanic and Atmospheric Administration

Education

Ocean Acidification: Building Blocks of the Sea

Grade Level

- 4-8

Timeframe

30-45 minutes

Materials

Legos (many of 3 distinct shapes)

- identify Legos of certain shape and color that will represent Calcium (Ca^+), Carbonate (CO_3^-), and Bicarbonate (HCO_3^-) respectively
- can label via letters, carbonate can be uniquely shaped (can have same color as Calcium- as they are compatible and bicarbonate and calcium are not), and Carbonate and Bicarbonate can have same shape but different colors

Visuals of organisms with $CaCO_3$ shells/skeletons (example in "Materials" section below)

Essential Question

How does ocean acidification affect marine animals with shells and skeletons?

Activity Summary

Human actions on land are connected to changes in the atmosphere, and thus, the ocean. The health and survival of ocean creatures is at risk because of the change in the ocean's chemical composition due to additional carbon dioxide that is dissolved into sea water from the burning of fossil fuels and land use changes. This change in the ocean's composition disrupts the ability of organisms with skeletons and shells to grow, due to a change in the availability of a building block crucial to shell and skeleton growth- calcium carbonate. This change can impact the ocean's food web and the food we eat. We can reduce our carbon footprint in many ways to help maintain the ocean's composition now and into the future.

Learning Objectives

Students will be able to:

- Understand and value the importance of how human activities influence the chemistry and thus health of the ocean ecosystem and organisms.
- Understand and value the importance of how changes in the ocean ecosystem affect marine life (specifically calcium carbonate building) and human life.

Background Information

The increase of carbon output is affecting not only our atmosphere, but our oceans as well. The ocean is sometimes referred to as a carbon sink, a helpful buffer against global climate change. In fact, the ocean absorbs approximately 1/3 of all CO_2 emissions. However, once dissolved in the ocean, CO_2 still makes a significant impact. It binds to water molecules to produce carbonic acid (H_2CO_3), which can then disassociate into H^+ and HCO_3 (bicarbonate). $CO_2 + H_2O$ H_2CO_3 $H^+ + HCO_3$. So, what does this mean? More H^+ ions mean a lower pH, or, in other words, a more acidic ocean. pH is measured by the number of H^+ ions present in a solution and can range from 1-14, with 1 being the most acidic and 14 being alkaline (basic). Distilled water is neutral, with a pH of 7.0. In pre-industrial times, ocean water had a pH of 8.2. Today, the ocean's pH is 8.0, and it is projected that if we maintain our current CO2 emissions, pH will drop to 7.7 by the year 2100. If that does not seem overly drastic, consider this: a drop of one pH unit represents a 10-fold increase in acidic H^+ ions. An increase in H^+ ions creates two problems. Not only is the ocean's pH dropping, which can cause the corrosion of the shells and skeletons of many marine animals, such as snails and corals, but the extra H^+ ions also tie up carbonate (CO_3). When available, carbonate can combine with calcium to form calcium carbonate ($CaCO_3$), an important compound used by many organisms as a building material for their shells and skeletons. Currently, coralline algae, corals, some species of snails, and many important planktonic species are being affected by the reduced availability of this important building compound. As corals and coralline algae disappear, so do the many marine animals that rely on them for habitat. While we can talk definitely about the effects of more acidic water and less available calcium carbonate on certain species, we also know that the repercussions of dissolved CO_2 in our ocean do not end there. A change in pH can affect respiration and reproduction. It can cause stress to organisms, and affects the nitrogen cycle. Most aquatic species are adapted to a specific range of pH, and the current anthropogenic change is happening more rapidly than any natural flux ever has, including a low pH interval some 55 million years ago, known as the Paleocene-Eocene Thermal Maximum, which caused a major marine die off. The effects of our carbon emissions on the ocean will therefore be amplified by the simple fact that organisms do not have time to evolve with the change.

Values

<u>Interconnected</u> – Even though humans don't spend the majority of our time in the ocean, our actions on the land affect the atmosphere (air) and thus, the ocean.
<u>Stewardship</u> – It is our responsibility to take care of the ocean by our actions on land
<u>Simplifying models</u> – The ocean is composed of building blocks for the organisms that live within it
<u>Causal chain</u> – burning fossil fuels emits CO_2 → the ocean absorbs CO_2→ the ocean becomes more acidic → a key building block for shells and skeletons, calcium carbonate, is not readily available → it is more challenging for calcifying animals to build their shells/skeletons → the food web is disrupted→ the food we eat could change

Vocabulary

Ocean Acidification - decrease in pH of the ocean caused by the uptake of atmospheric carbon dioxide

pH - a logarithmic scale of hydrogen ion concentration

Anthropogenic – caused or produced by humans

Fossil Fuels – any combustible organic material derived from the remains of former life (i.e. oil, coal, or natural gas)

Carbon Dioxide - A colorless, odorless gas present in the atmosphere

Solutions

To leave more building blocks in the sea for those animals with shells and skeletons we can

- Community Level Solutions – support increased public transportation use, support renewable energy, support local community with local purchases, support community garden programs

- Individual/Household Solutions – unplug vampire electronics (phone chargers, computer, laptops); reduces CO_2 and saves on the electric bill, reusable water bottles

Key Messages

- The ocean is a vital part in the Earth's ecosystem and are a home to marine life that contribute to the health of human life on our planet.
- Human actions are changing the ocean's chemical compositions which is altering life below the surface and could potentially change food webs and the food we eat
- We want to make sure that our ocean marine life remains healthy

- Together, we can work as stewards of our planet's oceans and make positive changes in the world we live.

Procedure

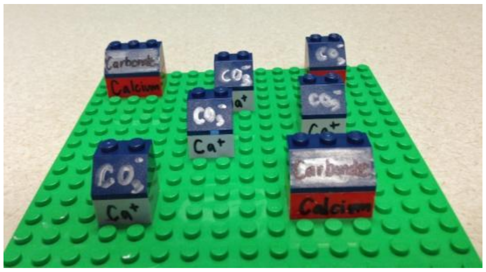
1. Create two piles of legos or "oceans"

- one representing an "acidified" ocean (future atmospheric CO_2 levels) with less carbonate lego and more bicarbonate pieces, set amount of Calcium pieces

2. Create a “pre-industrial revolution” ocean (with lower CO_2 levels) with more carbonate pieces and less bicarbonate, with same amount of calcium pieces

3. Students or small group of students can decide which shell or skeleton building creature they’d like to become (i.e. clam, oyster, lobster, coral polyp, pteropod etc.)

- You can highlight that these are sessile organisms that deal with what is available can’t travel to a different part of the ocean



4. Students or a small group of students build a calcium carbonate shell/skeleton by connecting the calcium lego pieces to the carbonate pieces in the pre-industrial ocean and then repeat in the “acidified” oceans

- Analogy: this is much like building a home or foundation for a home, a nail is needed to hold together the wooden frame or mortar to hold together bricks, just as carbonate is needed to create the foundation (skeletons of corals) or home itself (bivalve and mollusc shells)
- You can have groups compete in the two different oceans, how many healthy organisms were you able to build, or can time the different oceans as well.

Education Standards

Common Core ELA Standards	Informational Text Grades 4-8: 1 – Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text 4 – Determine the meaning of general academic and domain-specific words or phrases in a text 7 – Interpret information presented visually, orally, or quantitatively and explain how the information contributes to an understanding of the text in which it appears. Writing Standards Grades 4-8: 1 – Write opinion pieces on topics or texts, supporting a point of view with reasons and information 2 – Write informative/explanatory texts to examine a topic and convey ideas and information clearly • 4 – Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.
Common Core Math Standards	Mathematical Practices: Reason abstractly and quantitatively • Construct viable arguments
Next Generation Science Standards	4 Structure, Function, and Information Processing 4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction Science and Engineering Practices: Engaging in Argument from Evidence Crosscutting Concepts: Cause and Effect Systems and System Models 3-5 Engineering Design 3-5ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. Science and Engineering Practices Constructing Explanations and Designing Solutions Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World MS Human Impacts MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment Science and Engineering Practices: Constructing Explanations and Designing Solutions Crosscutting Concepts: Cause and Effect Influence of Science, Engineering, and Technology on Society and the Natural World •
Ocean Literacy Principles	• 5 The ocean supports a great diversity of life and ecosystems • 6 The ocean and humans are inextricably interconnected
Climate Literacy Principles	3 Life on Earth depends on, is shaped by, and affects climate A,C,E 6 Human activities are impacting the climate system C,D,E

Evaluation

1. Compare the two oceans?

a) How many calcium carbonate pieces were you able to put together to build your shell/skeleton in the different oceans?

b) Which ocean was it easier to find the building blocks of your shell/skeleton?

c) In which ocean were you able to put together your building blocks more quickly?

d) The time lost in searching for carbonate ions instead of bicarbonate.

e) If you were a _________, which ocean would you rather live in or would it be easier to build your shell/skeleton in?

f) What can we/you as humans do to help ocean creatures be able to build shells/ and skeleton/homes more easily?

Extensions

Students will read Earth's Acid Test published in Nature March 10, 2011 and answer questions about the text.

Students will explore the http://www.cisanctuary.org/ocean-acidification/ Web site (with supervision of teacher) to learn more about ocean acidification.

Investigate what other types of organisms may be the first to be affected by ocean acidification and why.

Utilize the International Student Carbon Footprint Challenge website (http://footprint.stanford.edu/calculate.html). Students will investigate how to calculate their own carbon footprint and develop and present ideas on how they individually, as a family, and as a school community can lower their carbon footprint and help decrease the amount of CO_2 (produced by the burning of fossil fuels) being absorbed by the world's oceans. Have students present and compare their solutions to reduction of carbon footprint and have them use individual plans to come up with the best overall plan. For middle and high school students have students devise a way to evaluate the effectiveness of their solution(s).

Students will explore ways they can effect change in the use of fossil fuels beyond their home and school communities.

Share portions of archived SOARCE (Sharing Ocean Acidification Resources for Communicators and Educators) Ocean Acidification webinars with students.
http://oceanacidification.noaa.gov/AreasofFocus/EducationOutreach/SOARCEWebinarSeries.aspx

Materials:

Resources:
http://www.cisanctuary.org/ocean-acidification/
http://oceanacidification.noaa.gov/

Credits: NOAA Ocean Acidification Program, additions and correlation to Common Core and Next Generation Science Standards by Maria Petueli. Email noaa.oceanacidification@noaa.gov with any questions.