How can growing seaweed help mussels?

	Time	Grade Level	Content Area (s)
	90 minutes	MS	LS, ESS, ETS1

Overview

Ocean acidification is occurring because our ocean is absorbing carbon dioxide from the atmosphere, leading to lower pH and greater acidity. This is causing a fundamental change in the chemistry of the ocean from pole to pole.

Lesson-level Performance Expectation (Lesson Objective):

Develop and use a model to explain how the **process of photosynthesis can be used as a possible solution to the problem of ocean acidification** in this **aquatic system**.

Lesson Summary

1. Students record and share observations about marine shells.
2. Students watch the film *Our Beautiful Planet Superpowers of Seaweed* and try to identify the problem with shellfish occurring in the Gulf of Maine.
3. Students develop a model and record information they think might be needed to design a solution to the problem of some ocean animals growing thin, brittle shells because of ocean acidification.
4. Students work in small groups to develop investigative questions and generate ideas to figure out how to keep the ocean from becoming more acidic.
5. Students figure out that ocean acidification is largely a result of human activity and revise their models to explain how their design solution solves the problem of ocean animals growing thin, brittle shells because of ocean acidification.

Materials

Per student or pair of students

- Our Beautiful Planet The Superpowers of Seaweed film
- Marine shells (mussels, clams, oysters, etc.) or photographs of shells
- Whiteboard or Poster paper

NSTA Collection of Resources for Today's Daily Do

NSTA has created a How can growing seaweed help shellfish? collection of resources to support teachers and families using this task. If you're an NSTA member, you can add this collection to your library.

nsta National Science Teaching Association

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
Asking Questions and Defining Problems Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. **Developing and Using Models** Develop and/or revise a model to show the relationship among variables, including those that are not observable but predict observable phenomena. **Constructing Explanations and Designing Solutions** Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system.	**LS1 Ecosystems: Interactions, Energy, and Dynamics** **LS1.C: Organization of Matter and Energy Flow in Organisms.** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. **ESS3: Earth and Human Activity** **ESS3.D: Global Climate Change.** Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. **ETS1: Engineering Design** **ETS1.B: Developing Possible Solutions.** Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.	**Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Systems and System Models** Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy, matter, and information flows within systems.

This lesson could be one in a series of lessons building toward this performance expectation (PE).

MS.LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

[Clarification Statement. Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

[Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

MS-ETS1-3. Analyze data from tests to determine similarities and difference among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Safety

NSTA encourages K–12 teachers and school leaders to promote and support the use of science activities in science instruction and work to avoid and reduce injury. Additionally, NSTA recommends teachers and school leaders visit the NSTA Safety Resource page for up-to-date information on safety issues and guidelines.

S = Students T = Teachers

Phenomenon

Shells of mussels living in the Gulf of Maine are thinner and more brittle than in the recent past.

Experiencing the Phenomenon

Students get direct experience with a phenomenon that is relevant to them. Students generate question(s) that are used to drive the lesson.

1. Begin by having students make and record observations about marine shells (clam, mussel, snail, etc.).

2. Prompt students to think about and discuss how marine animals use their shells and how their shells are made.

   S Students will...

   - Make and record observations about marine shells (clam, mussel, snail, etc.).
   - Share their observations with a partner.

   T This can be done by having students look at pictures of shells, but works best if students can observe different types of shells firsthand.

3. Bring students back together and have them share their noticings and ideas about shells.

4. Move the discussion forward by asking students to share their ideas about how shells are made.

   S Share their noticings and ideas about shells.

   T Common noticings will likely include these:

   - Students sharing that animals live in these shells and use them for protection.
   - Students talking about eating or being allergic to shellfish.

Using Artifacts and/or Discussions to Formatively Assess Student Learning

Many opportunities exist within the lesson to formatively assess student learning. One example is described below.

Artifact/Discussion: Revised Models (proposed solutions)

Look and Listen Fors:

- the increase in the amount of carbon dioxide transferred from Earth's atmosphere to the world's oceans causes an increase in ocean water acidity
- plants use carbon dioxide and release oxygen
- an increase in the number of plants on the land decreases the amount of carbon dioxide in Earth's atmosphere
- a decrease in the amount of carbon dioxide entering the world's oceans decreases ocean water acidity and increases the availability of carbon which animals need to build thicker shells

5. Share with students that scientists are noticing a problem with the shells of animals living in the world's oceans.

6. As they watch the film, tell students that they will try to identify the problem occurring in the Gulf of Maine and ask them to record any information they think might be needed to design a solution to that problem.

   S Record information they think might be needed to design a solution to that problem.

   T Play Our Beautiful Planet The Superpowers of Seaweed from 1:18 to 4:19.

7. Assign students to small groups and ask them to define the problem presented in the film and record their thinking on a whiteboard or poster paper.

S Work in small groups to define the problem presented in the film and record their thinking.

8. **Bring the class back together and have each group share the problem they identified including any criteria and/or constraints they determined from the information provided in the film.**

9. **After each group has shared, have the class work together to reach agreement on the problem to be solved.**

T Additional teacher guidance...

- The class will likely come to consensus on the following (or very similar) problem: Some ocean animals are having trouble growing shells because of ocean acidification.
- It is not necessary for students to have a robust understanding of the effects of ocean acidification on marine life.

10. **Ask students to return to their small groups to develop a model to explain how ocean acidification affects the growth of shells. You may want to play the film clip a second time.**

11. **Give each group two minutes as each group shares their model, task the groups to note similarities and differences between the model being shared and their own.**

12. **Provide time for the listening groups to provide feedback to the presenting group.**

S Note similarities and differences between the model being shared and their own

T Feedback may include one thing they like about the model and questions about the model.

13. **After all of the groups have shared, work with the class to develop investigative questions.**

14. **Ask students to identify areas of disagreement among the groups' models.**

15. **Ask: "What questions do we have about how ocean acidification affects the growth of shells?"**

16. **Ask: "What other information do we need to know to create a solution to this problem?"**

S Work together as a class to develop investigative questions

T Student questions may include

- How can what's in the air affect what happens under water?
- How does carbon dioxide get into the water?
- Can you take carbon dioxide out of the water?
- How do shellfish make their shells?
- How can animals turn ocean water into shell?

Depending on prior learning, the answers to some of the questions students ask may or may not be accessible to them.

Middle school students may have very limited experience with chemical reactions, so they would not have the background knowledge necessary to explain how shellfish use substances dissolved in ocean water to create their shells.

Students as Scientists

Students engage in science and engineering practices to develop and/or use science ideas needed to explain how or why the phenomenon occurs.

17. **Tell students, "We need to figure out which question to focus on to help us solve the problem we defined in the lesson: Some ocean animals are having trouble growing shells because of ocean acidification."**

18. **Tell students that to develop a solution to a problem, we need to know what the goal is or what the final outcome should be.**

19. **Ask: "What do you think the goals of the solution to our problem should be?"**

20. **Have students share what they think the goal is and focus on the goal of animals growing hard shells**

T As students share ideas, use prompts such as

- "Does anyone else agree with this goal or have a similar idea?"
- "Can you tell me more about why you think this should be the goal?"

- "How would that outcome help the shellfish or the mussel farmer?"

21. **Lead students to reach an agreement that the goal is to "fix" or treat the water so animals can grow and maintain thicker, less brittle shells.**

22. **Prompt them to think about the relationship between growing and maintaining shells and ocean acidification.**

23. **Ask students: "What needs to change so the animals can grow thicker, less brittle shells?"**

    T Students should conclude that the water needs to be less acidic so the shells can grow.

24. **Tell students you would like them to represent this new idea in their model**

    S Students will...

    - Add their ideas about the interactions between the different components in the water and how they might affect shell development and maintenance.
    - Add to or change their models, representing this interaction in various ways

    T Additional teacher guidance...

    - Students will represent this interaction in various ways but all representations should be similar in that they communicate the following pattern: When carbon dioxide moves from the air to the water the ocean becomes more acidic and the shells animals make get thinner and more brittle.
    - Middle school students can use general descriptions like "more acidic" and "less acidic" as the chemical reactions taking place in the water are out of scope for this grade band.
    - Middle school students need opportunities to look for and identify patterns that they can use to begin to explain phenomena.

25. **Have students work in small groups and make a list of information they think is important for them to consider in reaching the goal.**

26. **Tell students information may come from the film, class models, and ideas shared in discussion.**

    S Working in small groups, make a list of information they think is important for them to consider in reaching the goal.

    T Now that students have established a goal, they need to figure out what they know and what they still need to figure out.

27. **Ask students to brainstorm ideas of how to keep the ocean from becoming more acidic.**

28. **Ask groups to share one piece of information, taking turns until all information has been shared. Record information as it is shared.**

    S Each turn, share one piece of information until all information has been shared (all new information is represented on the class record).

    T Information should include:

    - The water is getting more acidic because of carbon dioxide
    - Carbon dioxide in the air (from factories, cars, etc.) gets into the water
    - Shells can't grow well because of the change in the water
    - Ocean acidification affects many things not just mussels

29. **Acknowledge that these ideas would keep the ocean from becoming more acidic, but could take a very long time to implement.**

30. **Ask students if there are other ways to reduce the amount of carbon dioxide in ocean water.**

31. **Bring students back together to share their ideas**

    S Students will...

    - Review as a whole class what they know about the cycling of matter
    - Work with small groups to brainstorm ideas about organisms that use carbon dioxide to survive

    T Additional teacher guidance...

    - Students will say that they need to keep carbon dioxide out of the ocean and that they need to stop putting so much carbon dioxide in the air.
    - Note: In NGSS, matter cycling is identified as a Grade 5 DCI.

- Students also come to understand that plants obtain matter chiefly from air and water. Although carbon dioxide is not explicitly called out as a gas used by plants, many students will have been exposed to the idea that plants use carbon dioxide and release oxygen.
- Student's ideas will likely center around plants. They may suggest planting trees, flowers, and other plants around or in the water.
- Students will often say that shellfish can't grow shells or state that the shellfish won't grow shells if the ocean is too acidic.
- When students use statements like the examples here, prompt them to think about the terms 'won't and can't'.
- Ask students what evidence they have to support their statements or if they need to revise their statements to make them scientifically accurate.
- You can also refer them to the problem we are trying

32. **Acknowledge that planting trees, flowers, and plants in the ground along the coast of the ocean will help remove carbon dioxide from the air.**

33. **Have students revisit their model to add this idea.**

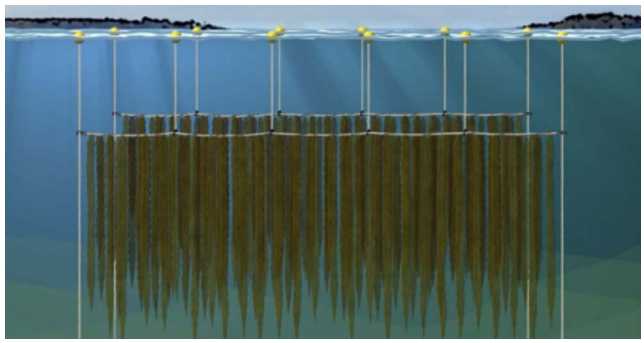
34. **Remind students to represent the interaction between carbon dioxide in the atmosphere and plants using words, symbols and pictures.**

35. **Consider pairing groups together and having them share what they added to or changed on their models and why.**

    T Additional teacher guidance...

    - As students are revising their models, walk around the room and use this as an opportunity to formatively assess students' prior learning.
    - Look for them to include carbon dioxide going into the plant (input) and oxygen being released (output) and representing carbon as staying behind/becoming part of the plant.

36. **Ask students to use the big science ideas around matter cycling and where plants obtain matter to design a solution that could help solve the problem of increased ocean acidity.**



The Superpowers of Seaweed-Mussel farm graphics 02

37. **Share their design solutions with the class and allow students to ask clarifying questions.**

    S Students will...

    - Use big science ideas around matter cycling and where plants obtain matter to design a solution that could help solve the problem of increased ocean acidity.
    - Share their design solutions with the class and allow students to ask clarifying questions.

    T Student groups will most likely develop a plan to grow plants in the water because the plants use/need the carbon dioxide and release the oxygen (which fish and other organisms need).

38. **After students share their design solutions, play the entire *Our Beautiful Planet* The Superpowers of Seaweed film for the students.**

    T *Our Beautiful Planet The Superpowers of Seaweed* film

Reflecting on the Phenomena

What have we figured out? What new questions do we have? Where do we go next?

39. **After students watch "The Superpowers of Seaweed" film, have a class discussion about the information they gathered from the remainder of the film.**

40. **Ask students if the information from the film supported or refuted their design solution.**

41. **Have students create a new model to explain how their design solution solves the problem identified at the beginning of the lesson:**

Some ocean animals are having trouble growing shells because of ocean acidification.

42. Remind students to use words, pictures and symbols to explain how their solution can reduce the amount of carbon dioxide (make the water less acidic) and improve shell growth.

43. Next have students work in small groups to identify the different cause-and-effect relationships they considered throughout their learning.

S Students will...

- Create a new model to explain how their design solution solves the problem identified at the beginning of the lesson.
- Some ocean animals are having trouble growing shells because of ocean acidification.
- Use words, pictures, and symbols to explain how their solution can reduce the amount of carbon dioxide (make the water less acidic) and improve shell growth
- Work in small groups to identify the different cause-and-effect relationships they considered throughout their learning.

T These are not if/then statements.

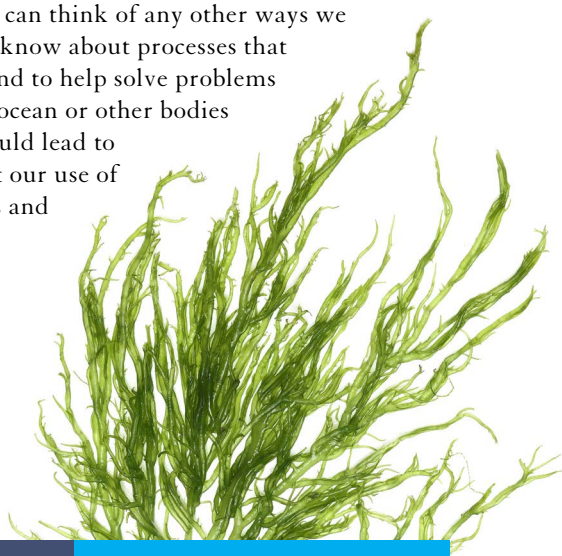
- Students should use their models, information from The Superpowers of Seaweed film, and ideas shared in class discussion to begin to explain the cause-and-effect relationships in their own words.

Common student statements include:

- Mussels that grew in more acidic water had shells that broke more easily.
- Plants take CO2 out of the air and out of the water so there was less carbon dioxide
- The water was less acidic when the kelp was growing near mussels in the farm.
- The mussel shells grown near kelp were thicker because the kelp took carbon dioxide out of the water.
- Middle school students are likely to believe kelp, the seaweed featured in the film, are plants.
- Kelp are algae, as are many kinds of seaweed. Use this opportunity to introduce students to the idea that other organisms besides plants carry out photosynthesis and algae are one example.
- Students in middle school will likely understand plants (and kelp) use carbon dioxide in the process of photosynthesis.
- They will very probably assume the decrease in carbon dioxide levels in ocean water near the kelp farms means the amount of carbon dioxide in the atmosphere also decreased (see example student response above) because of their experience with land plants removing carbon dioxide from the atmosphere.
- If students make this comparison, consider asking them to clarify their statement as a claim or prediction and ask them to provide evidence to support their idea.

Next Steps and Extension Activities

Through this design project, students figure out that aquatic and terrestrial systems work in similar ways. Ask them if they can think of any other ways we can use what we know about processes that happen on the land to help solve problems occurring in the ocean or other bodies of water. This could lead to discussions about our use of natural resources and about pollution.



About the *Our Beautiful Planet* Film Series

This lesson is based on information provided in *Our Beautiful Planet The Superpowers of Seaweed*. *Our Beautiful Planet* is a fascinating new series highlighting the work that climate scientists around the country are doing to solve some of the world's most pressing issues. These dedicated scientists are seeking to better understand and plan for the realities of our changing climate. Using cutting edge technology and innovative problem solving, their answers are sometimes found in rather surprising and unexpected places. Our series brings the viewer along for the ride to some of the most important field work being done today, taking the science out of the classroom and into the world. These compelling stories will not only teach our viewers crucial scientific principles, but will also inspire them to use science to examine the issues their own communities face in this changing world and climate. Through these films, we hope scientists and citizens alike can come together to safeguard our environment and to protect our beautiful planet. Productions by Kikim Media. Support provided by Kennebunkport Climate Initiative.

KIKIM MEDIA

KENNEBUNKPORT CLIMATE INITIATIVE

Meet the Scientists from *Our Beautiful Planet*

Susie Arnold

As the marine scientist at the Island Institute, Arnold works on the impacts of climate change and ocean acidification on Maine's marine resources and fisheries-dependent communities.

Through her work, Arnold is helping coastal communities better understand the implications of ocean climate change so they can make informed decisions about adaptation. She is also conducting applied research to understand the environmental benefits of kelp farming, including its ability to remediate ocean acidification. With recent appointments to the legislatively established Ocean Acidification Commission as well as to the Maine Climate Council's Scientific and Technical Subcommittee, and as liaison to the Coastal and Marine Working Group, Arnold has emerged as a leader at the interface of science and policy in Maine. Before joining the Island Institute, Arnold earned master's degrees in marine biology and marine policy and a doctorate in marine biology from the University of Maine. Her research focused on coral reef ecology and the importance of protecting certain fish species for the well-being of the entire ecosystem, including those who make a living from the ocean.

Nichole Price

Nichole Price is a senior research scientist and benthic marine ecologist at the Bigelow Laboratory for Ocean Sciences. She studies how global change phenomena, like ocean acidification and warming, can alter bottom-dwelling species interactions, community dynamics, and ecosystem function in shallow coastal regimes. Her work focuses primarily on the eco-physiology of seaweeds and their current and future role in dissolved inorganic carbon cycling. She is interested in understanding how the balance of primary production/respiration and calcification/dissolution create natural diel variation in carbonate chemistry and perpetuate biological feedbacks. She has focused on these topics primarily with regard to tropical coral reefs, but has also recently expanded her work to include temperate systems. Price's research uses state-of-the-art analytical tools, including novel autonomous instrument packages and custom experimental aquaria, and extrapolates results to regional and global scales using statistical modeling.

Learn More

www.kikim.com • www.kportclimate.org