



Protecting our Oceans and Ourselves: Coastal Resilience and Restorative Aquaculture TEACHER'S GUIDE

Grades: 8-12

Subjects: Science and Geography

Purpose: This guide contains a set of discussion questions and answers for any grade level, which can be used during and after the virtual field trip. It also contains links to additional resources ranging from lessons, activities, videos, demonstrations, experiments, and multimedia presentations.

Essential Question: How can nature-based solutions be used by coastal communities to mitigate the impacts of climate change?

Supporting Questions:

- How does climate change impact our oceans?
- What is coastal resilience?
- How can coastal communities become more resilient in the face of climate change?
- What natural solutions can improve coastal resilience?
- What can we do at home to help protect our world's oceans?

Description:

More people rely on our ocean for food, energy, transport, recreation, and other natural resources than any other time in history. Effective efforts to protect our oceans so that we can continue to rely on them include coastal resilience improvement efforts such as coral reef and mangrove restoration, and restorative aquaculture, which supports seafood sustainability and healthy coastal ecosystems. A future where people and oceans thrive together IS possible if we take the right steps.

Materials

Video supporting this lesson plan:

- *Protecting the Ocean and Ourselves: Coastal Resilience and Restorative Aquaculture*
 - Vimeo: <https://vimeo.com/754349752>
 - YouTube: <https://youtu.be/bORDGIDMxZY>

Materials for Teachers:

- Computer with Internet connection, LCD projector, screen

Materials for students:

- If remote, students can use the online Docs version of the discussion questions worksheet. Make a copy to distribute digitally to students:
<https://docs.google.com/document/d/1DGtVlg16kBB5yzDwicChMtRVFpQw8Cu5qijl0mS8-RQ/edit?usp=sharing>
- Kahoot: <https://create.kahoot.it/profiles/c31cef38-5ae4-4c5e-8f4d-5462323ef688>

Standards:

Next Generation Science Standards:

Disciplinary Core Ideas:

ESS2.D: Weather and Climate

ESS3.C: Human Impacts on Earth Systems

ESS3.D: Global Climate Change

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

LS4.D: Biodiversity and Humans

ETS1.B: Developing Possible Solutions

Crosscutting Concepts:

Cause and Effect

Stability and Change

Science and Engineering Practices:

Analyzing and interpreting data

Constructing explanations and designing solutions

Engaging in argument from evidence

Developing and using models

Common Core Standards:

Grades 9-10

CCSS.ELA-LITERACY.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-LITERACY.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

CCSS.ELA-LITERACY.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-LITERACY.RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS.ELA-LITERACY.RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Grades 11-12

CCSS.ELA-LITERACY.RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

CCSS.ELA-LITERACY.RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

CCSS.ELA-LITERACY.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

CCSS.ELA-LITERACY.RST.11-12.8

Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

CCSS.ELA-LITERACY.RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

AP Environmental Science

Ecosystem Diversity – Ecosystem Services

Global Change – Impacts and Consequences of Global Warming, Reducing Climate Change

Vocabulary:

- **Carbon sequestration:** A process of removing carbon dioxide from the atmosphere
- **Carbon storage:** Carbon dioxide stored within trees, plants, water, and other spaces
- **Climate:** The weather conditions in an area over a long period of time
- **Mitigation:** an action that reduces the severity or harm of an impact
- **Nature-based solutions:** a broad term that refers to solutions that rely on nature
- **Natural climate solutions:** actions that are nature-based and increase carbon storage or avoid greenhouse gas emissions to tackle climate change
- **Resilience:** the capacity to recover quickly from difficulties
- **Run-off:** Water that drains into streams and rivers following rainfall
- **Global climate change:** change in average global temperature, rainfall, and wind patterns as a result of increased greenhouse gases in the atmosphere
- **Greenhouse gases:** gases in Earth's atmosphere that trap heat
- **Density:** a measurement of compactness, measured as mass per unit volume
- **Displacement:** the forced relocation of water due to a submerged or partially submerged object
- **Overfishing:** Overfishing is the removal of a species of fish from a body of water at a rate greater than that the species can replenish its population naturally

Discussion Questions: After/during watching [Protecting the Ocean and Ourselves: Coastal Resilience and Restorative Aquaculture](#), use these questions to check for understanding and dive deeper into these topics. You can use or adapt these questions for a follow-up discussion with your students after viewing the virtual field trip or you pause as you go along.

1. What is one way humans impact the ocean?
Answer: By producing greenhouse gases that trap heat, which in turn warms water that then expands and melts polar ice, contributing to sea level rise.
2. Why has the ocean become more acidic?
Answer: Because humans have caused more carbon dioxide to be released and when carbon dioxide combines with water, it makes a molecule called carbonic acid.
3. How is damage to ocean ecosystems impacting Florida?
Answer: Florida's coral reefs have been impacted by warming and disease. Its fish populations – grouper, and snapper for example – have decreased, and the effects of sea level rise have led to more flooding.
4. Does sea level rise affect all places equally? Explain.
Answer: No, In a place with steep shorelines, the ocean may rise, but won't affect land further in. In low-lying places like Florida, a little bit of rise can spread far inland.

5. How can nature help communities resist damage from hazardous events such as hurricanes, coastal storms, and flooding, and to bounce back afterwards?
Answer: Nature in the in the form of oyster reefs, coral reefs, mangrove forests, salt marshes, coastal forests, they all provide coastal resilience benefits or adaptation benefits because they can reduce the energy of the storm surge, the wave energy that can reduce the wind energy and that can also help with coastal flooding.
6. Explain how marsh cord grass is beneficial to Florida’s coastal communities.
Answer: Marsh cord grass is a native grass here at Blowing Rocks Preserve, it grows naturally along this Indian River shoreline that we’ve got, and it’s really important for preventing erosion, and then stabilizing the shoreline, and providing some habitat for wildlife. Marsh cord grass keeps the coastline intact and keeps it healthy and resilient as Florida gets bigger storms and sea level rise and climate change continue. This natural infrastructure is the first line of defense.
7. What are some benefits of mangrove trees in tackling climate change?
Answer: Mangrove trees help stabilize the shoreline and sequester carbon.
8. Explain the role of mapping tools in using natural solutions effectively.
Answer: Mapping tools help find the most at-risk areas, those that are most able to be restored, and what solutions might work best in each place.
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Answer: Mapping tools help find the most at-risk areas, those that are most able to be restored, and what solutions might work best in each place.
10. Explain the importance of shellfish reefs.
Answer: Shellfish reefs filter water and if the ecosystem is healthier, there will be more wild fish available for people to catch.
11. In what ways can aquaculture be **restorative** to the environment?
Answer: Shellfish and seaweed production requires almost zero feed, freshwater or land and releases almost no greenhouse gases. They also filter out nitrogen, an element that can cause harmful algal blooms. They also eat algae itself – a two-for-one!

Activity 1: Understanding Sea Level Rise

- Why does melting land ice causes sea levels to rise, but melting sea ice does not?
- What are the far-reaching effects of global climate change?

Do sea levels rise when ice melts? Does it matter whether the ice is on land or in the ocean? Students design an experiment to find out. They will collect data, graph their results, and interpret their findings while learning about density, displacement, and climate change.

Background & Directions

One consequence of climate change is the melting of ice caps, glaciers, and sea ice, including polar ice. Substantial melt of these massive glaciers will cause a rise in sea level along coastlines throughout the globe. Students will explore how melting ice impacts sea level.

Materials (per group)

- 2 identical clear food storage boxes (approximately 6 inches & square)
- 8 sticks of classroom modeling clay
- 1 ruler
- 1 tray of ice cubes
- 1 liter of water

Procedure

1. Place half of the clay into one side of each box. Form the clay to represent land rising out of the ocean.
2. Place about 6 ice cubes on the “land” in the first box. Place the same number of ice cubes next to the clay in the second box, so that they are resting on the bottom of the container.
3. Pour water into the container where the ice is resting on the bottom until the ice is floating (NOT resting on the bottom).
4. Pour water into the container with the ice resting on the clay until the water levels in the two containers are approximately equal.
5. Have students measure and record initial measurements of water depth (in mm). They may wish to draw a line in the clay at the initial water level.
6. Leave the setup. Students should measure the water depth every hour (or other regular interval) and record the results, until the ice is completely melted.

Data Analysis

1. Have each group graph their results on the board, on chart paper, or on butcher paper (see sample graph below) and display the graphs so everyone can see.
2. Tip: You may wish to draw the axes ahead of time so the students can simply fill in their data. Younger students might find it easier to place Post-It notes on the board (1 Post-It per mm water depth) to form the bar graph, instead of drawing the graph. With older students, you may wish to make a line graph instead of a bar graph.
3. Have each student write a conclusion summary on what happened and why.

Discussion

Lead a discussion about the results. This can be done in groups or as a whole class. Use the questions below to facilitate the discussion.

Explain as a refresher: Water expands when it freezes. In general, liquids do not expand upon freezing, but rather contract and become denser as temperature drops. Like other liquids, as water begins to cool, it becomes more and more dense. But, because of the physical structure of the water molecule, it continues to become denser until just before freezing, when it expands. This expansion occurs at the point at which freezing begins (around 4°C). At this temperature water molecules arrange themselves into a crystal lattice structure that is significantly **less dense** than the liquid form. Because of this **decrease in density** at the point of freezing, ice always floats on water.

Have another discussion about global climate change. Use the following questions to generate discussion:

1. Why might we be concerned about sea level rise?
Answer: Because coastal areas will be flooded. People will lose their homes. Some fresh water resources will become too salty to use and it will cause habitat loss over time.
2. What can we do to help slow this process?

Answer: We can decrease our personal fossil fuel use by taking public transit instead of driving, eating local foods, turning off lights and electrical equipment when not in use, getting involved in our communities, volunteering to do things like planting a tree, reusing things more often and recycling what we can.

Activity 2: Understanding how climate change impacts oceans

Background & Directions

No matter where we live, the ocean is essential to our lives. It supplies 50% of the oxygen we breathe and is the home to fish and other species that provide food and income for more than three billion people. Its coral reefs, oyster beds and kelp forests shelter marine life and protect our shores by breaking up wave energy and storm surges.

On the edges of the ocean, coastal wetlands—such as mangroves, salt marshes and seagrass meadows—protect our shores, too. They also draw in carbon as they grow and transfer it into their leaves, stems and the rich soils held by their roots. This “blue carbon” can remain in the soil for thousands of years. In fact, coastal wetlands store five times more carbon per hectare than rainforests, helping to limit further climate change.

Ask students to conduct a research investigation that will explore how climate change impacts oceans.

1. Each student group member will read a different article (below). Have students read the articles online, OR make a photocopied set for each group and distribute before beginning the activity.
 - "[Forests Reduce Ocean Acification and Climate Change](#)" The Nature Conservancy
 - "[Transforming Ocean Conservation in California](#)" The Nature Conservancy
 - "[A Conversation on Ocean Protection with Vikki Spruill](#)" The Nature Conservancy
 - "[How to Feed the Planet While Protecting the Ocean](#)" The Nature Conservancy
2. If students will read the articles online, pre-load the articles before class.
3. Have students work in pairs. Ask each student to summarize the article they read and share the information with the group. Distribute the "[3-2-1 Activity](#)" sheets and have each student to complete it based on all four articles.

Activity 3: Understanding shellfish reef ecosystems

Background & Directions

During the virtual field trip, we visited Australia and learned that shellfish reef ecosystems were once abundant and dominated many of the bays and estuaries. These ecosystems have largely disappeared. Up to 99% of these reefs have been lost. You can share this reminder with students or you can ask open-endedly: “What did we learn about shellfish reef ecosystems in Australia” and arrive at this refresher via a brief discussion. Now, students will understand why shellfish reef ecosystems are so crucial and how they can be powerful coastal resilience tools for communities.

In groups (groupings can vary depending on class size, multiple groups may have the same additional artifact), students will explore the various benefits of shellfish reefs. Distribute one artifact below to **each** group. Watch the virtual field trip one way through and ask students to take careful notes on shellfish ecosystem once again and then instruct each group to create a short 3-5 minute speech using their notes from the virtual field trip and the additional artifact. Groups should be prepared to deliver the speech to the class. Provide additional research artifacts if desired. The speech should answer the following prompt:

Why should we protect and restore shellfish reefs?

Every hectare of oyster reef (per year) would



FILTER

2.7 billion

litres of seawater



KG

REMOVE 225

Kilograms

of nitrogen and phosphate

PRODUCE



375kg

of new fish
to catch and eat

PROVIDE NEW HOMES FOR OVER



100

marine
species



7,000m³

of used shell, preventing it
from entering local landfill

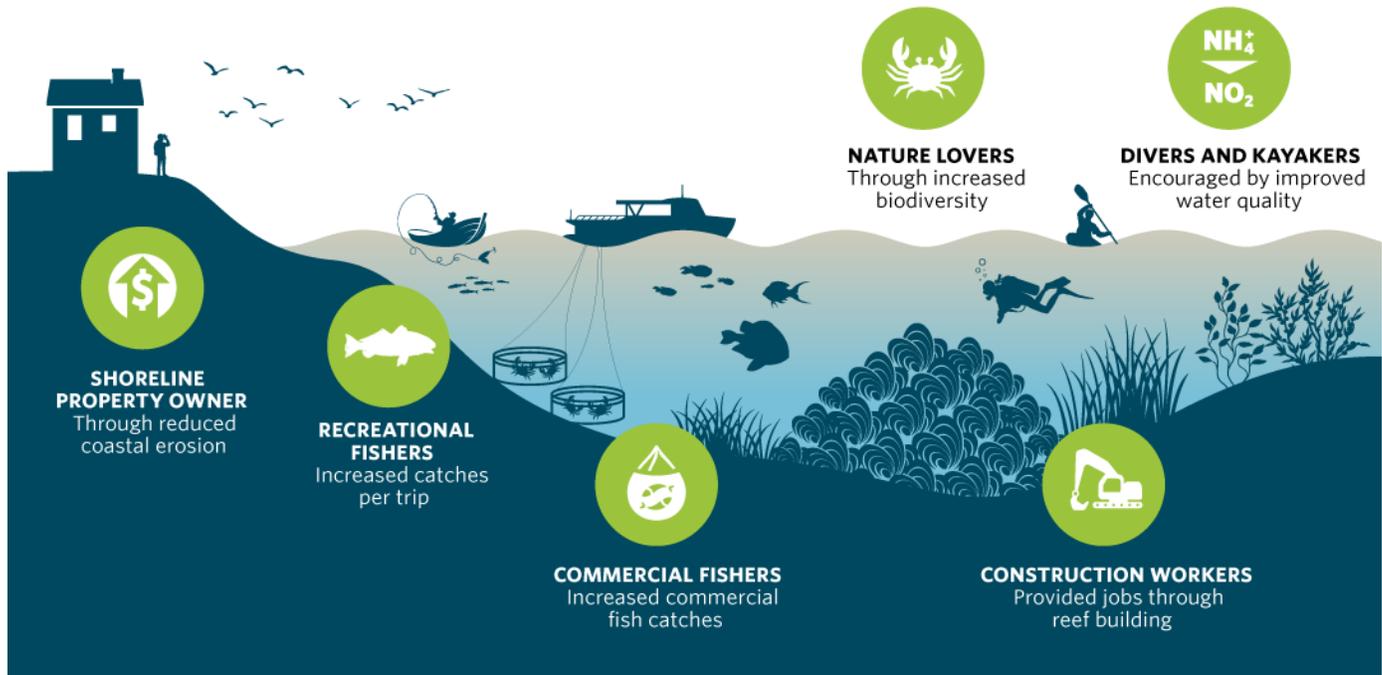
Artifact 2: Community benefits of shellfish reefs

Excerpt from [Reef Building, nature.org](#)

Building 60 Shellfish reefs can provide many benefits to people and communities, including:

Up to 850 jobs will be created in maritime construction, science, fisheries, and associated service sectors with half of these in regional areas.

7,000m³ of shell waste will be diverted from landfill, to be recycled into new reefs.
New community volunteering and education opportunities.



Artifact 3

Excerpt from [Reef Building, nature.org](#)

The loss of shellfish reefs results in the loss of the social and economic benefits they provide to people and nature. Fish stocks decline because fish have fewer places to breed, hide and feed whilst other marine life have no reef areas to colonize. Water quality also declines.

Shellfish such as oysters are excellent natural water filters. One adult oyster can filter up to a bathtub of water a day!

The removal of millions of shellfish caused the loss of a natural process that kept our coastal waters clean and clear. This also put our coastal communities at increased risk. As these reefs provide an important line of natural defense for our coastline—reducing coastal erosion and damage from storms.

How Reefs are Built:

1. First, we **identify suitable sites** for restoration using a combination of science, field surveys, and historical and contemporary knowledge provided by fishers, divers, boaties and scientists.
2. Next, we **create the reef base**. We lay natural materials on the seafloor. We often use a combination of limestone rubble and recycled shells, which mimic the foundations of a natural reef. This provides elevation and

hard surfaces that attracts marine life. The recycled seafood shells (oysters, mussels and scallop shells) are collected from local restaurants as part of our [Shuck Don't Chuck](#) shell recycling project.

3. Lastly, when there aren't enough oysters to allow natural repopulation, **we scatter the reef base with millions of baby oysters and mussels** grown in nearby hatcheries in partnership with shellfish farmers. These shellfish grow and attach to the reef base and each other. Over time, they create a living reef which further attracts a diversity of fish and aquatic life.

Scientists monitor reefs for several years after construction for threats such as predators and disease. We make adjustments to how the reef is constructed to ensure the reef grows and thrives into a natural, self-sustaining reef. This innovative approach is revitalising reefs from Noosa to Melbourne, from Adelaide to Perth.

The result is less waste to landfill, rejuvenated habitats for native species and improved economic outcomes for local communities.

Nature Lab Related Resources: The following lesson plans and videos can be used to supplement the virtual field trip.



Understanding Climate Change

Grade Levels: 9-12

Students will explore the relationship between weather and climate using local data to derive their own definitions. Students will examine the ways that humans have impacted Earth by analyzing real data and online interactives to discover why scientists are calling this the “Anthropocene.”

https://www.nature.org/en-us/about-us/who-we-are/how-we-work/youth-engagement/nature-lab/high-school-lesson-plans/?tab_q=tab_container-tab_element_1907393885



Coastline Erosion Protection

Grade Levels: 9-12

There are multiple ways to protect coastlines. In this lesson, students compare strong (but expensive) construction materials with the less robust (but cheaper) oyster reefs. Students use an online tool to find historic tide data in a selected coastal location and explore the use of different materials in protecting coastlines.

https://www.nature.org/en-us/about-us/who-we-are/how-we-work/youth-engagement/nature-lab/high-school-lesson-plans/?tab_q=tab_container-tab_element



How Water Works

Grade Levels: 3-8

By filtering rainwater and slowing the movement of water to rivers, lakes and oceans, your garden works as a mini-watershed. In this lesson, students calculate the permeable surface area of their garden and periodically measure rainfall amounts, acting as junior hydrologists.

<https://www.nature.org/en-us/about-us/who-we-are/how-we-work/youth-engagement/nature-lab/elementary-lesson-plans/>

Other Related Resources

Classroom Resources (All Grades)

- Social Justice and Climate Change: Sinking Cities (California Academy of Sciences)
<https://www.calacademy.org/educators/lesson-plans/global-climate-change-and-sea-level-rise>
- Restoring Australia’s Lost Shellfish Reef (TNC)
<https://www.nature.org/en-us/about-us/where-we-work/asia-pacific/australia/stories-in-australia/restoring-australias-lost-shellfish-reefs/>
- Aquaculture Could Feed the Planet (TNC)
<https://www.nature.org/en-us/what-we-do/our-insights/perspectives/aquaculture-could-feed-the-world-and-protect-the-planet-if-we-get-it-right/>
- A Food System to Restore the Planet (TNC)
<https://www.nature.org/en-us/what-we-do/our-insights/perspectives/regenerative-agriculture-food-system-restore-planet/>
- Ocean Exploration (NOAA)
<https://oceanexplorer.noaa.gov/edu/lessonplans/lessonplans.html>

Groups Advocating for Ocean Justice

- **World Ocean Day:** The World Ocean Day Youth Advisory Council helps develop World Ocean Day as a unique opportunity to raise the profile of our shared ocean, connect and unite youth and others around our blue planet, and focus collective action on creating a healthier ocean and climate in June and throughout the year.
- **Sunrise Movement** is a movement to stop climate change and create millions of good jobs in the process.
- **SustainUS** is a youth-led organization advancing justice and sustainability by empowering young people to engage in advocacy at the domestic and international levels.
- **Big Blue & You:** Big Blue & You is dedicated to inspiring and educating youth about OCEAN conservation through ARTS, SCIENCE and MEDIA.
- **Minorities In Shark Science (MISS):** MISS promotes diversity and inclusion in shark science.
- **Intersectional Environmentalist:** IE is a climate justice collective radically imagining a more equitable and diverse future of environmentalism.

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