Florida Keys National Marine Sanctuary

Photo: Greg McFall/NOAA

Grade Level
6-8

Timeframe
Two 45 Minute Sessions

Materials
Teacher Use: Computer, projector, and screen
Student computer access (1:1 or 1:2)
Student science journals or notebooks
Whiteboard and markers (1 per student)
Digital Materials (links provided):

- Mission: Iconic Reefs video
- 360° Coral Restoration video
- FKNMS Map
- Staghorn coral
- Elkhorn coral
- Restoring Coral Reefs video
- Cheeca Rocks Sanctuary
- Restoration Guidelines

Print Materials:

- Exploring Coral Restoration
- Coral Reef Ecology Webquest
- Designing a Coral Nursery
- Activity Rubric
- 8.5 x 11 in. ¼ in. grid paper

Photo: Mitchell Tartt/NOAA

Activity Summary

Students will research the ecology of coral reefs, natural and anthropogenic threats to corals, and the science of coral restoration.

In pairs, students will design and make an argument for a proposed new coral nursery to be placed within Florida Keys National Marine Sanctuary (FKNMS).

Learning Objectives

Students will be able to:

- Explain and discuss the importance of coral reefs in terms of ocean biodiversity
- Explain general characteristics of corals
- Describe natural and anthropogenic threats to coral reefs
- Explain the importance of coral restoration projects and the general process of coral restoration
- Synthesize their knowledge in order to design a plan for a new coral nursery and make reasoned arguments for its establishment

Background Information

Florida Keys National Marine Sanctuary

Designated on November 16, 1990, Florida Keys National Marine Sanctuary protects 2,900 square nautical miles of waters surrounding the Florida Keys, from south of Miami westward to encompass the Dry Tortugas, excluding Dry Tortugas National Park.

The shoreward boundary of the sanctuary is the mean high-water mark, essentially meaning that once you set foot in the waters of the Florida Keys, you have entered the sanctuary. Within the boundaries of the sanctuary lie spectacular, unique, and nationally significant marine resources including the only coral barrier reef in the continental United

Photo: NOAA

States, extensive seagrass beds, mangrove-fringed islands, and more than 6,000 species of marine life. The sanctuary also protects pieces of our nation's history such as shipwrecks and other archeological treasures.

Coral Reef Ecology

In warm, shallow waters, corals colonize rocky areas forming one of the most productive and diverse ecosystems in the world. Thousands of different organisms can be found on a single reef. Coral continue to build additional hard surface with their calcium carbonate skeletons. Twenty five percent of marine life lives together on coral reefs, yet coral reefs take up less than 2% of the seafloor. With so many different species and individuals, there are many opportunities for organisms to work together and to compete with one another. Coral reefs are rich with symbiotic relationships. Without them, the corals themselves would not exist as they do today. Living within the coral's tissue are tiny cells of photosynthetic algae called zooxanthellae. Corals and zooxanthellae have a mutualistic relationship where the coral provides the zooxanthellae with protection, carbon dioxide (CO_2), and nutrients, and the zooxanthellae provide the coral with energy in the form of food generated via photosynthesis.

Coral reefs are ecologically important for many reasons. They support incredible species diversity in an area which is naturally nutrient-poor.

There is high competition for space in coral reefs because sunlight is a prerequisite for growth and success. Many corals tend to grow upward then outward to maximize sunlight exposure. Corals act as a nursery for many juvenile animals. Their physical structure allows places to hide; many animals are adapted for maneuverability rather than speed to hide within coral branches.

Key Words

abiotic, acroporid corals, anthropogenic, biotic, biodiversity, coral bleaching, coral nursery, coral trees, ecosystem, ocean acidification, outplanting, reef building corals, substrate

Corals are environmental health indicators; they are incredibly sensitive to temperature, acidity, sedimentation, pollution, and eutrophication. Eutrophication is an excess of nutrients (usually nitrogen and phosphorous) that can cause algal blooms. An excess of algae is harmful to coral reefs because the algae will out-compete them for space and sunlight, causing mass die-offs. Increased water temperatures can break down the relationship between coral and their symbiotic zooxanthellae, resulting in bleaching. Bleached corals are also very susceptible to algae overgrowth because they are in a weakened state. Acidity is increasing in the ocean (which means the pH is dropping), and this spells trouble for organisms which utilize calcium carbonate skeletons (corals, bivalves, crabs, etc.). Calcium carbonate becomes weakened in more acidic water, which leads to dissolving of the very backbone of the reef. Human impacts, including pollution, oil spills, microplastic and microplastic (plastic pieces less than 5mm), and overfishing, can also devastate coral reefs. Some ways to keep reefs healthy include sustainable fishing, marine protected areas, a reduction in single-use materials, and curbing our emissions of greenhouse gases.

Coral Restoration

To help replenish wild populations of corals that have been degraded due to natural or anthropogenic impacts, researchers grow corals in underwater nurseries. Nursery sites are ideally easy to access, protected areas with natural light availability, stable water temperature and flow, salinity, sedimentation, and turbidity that are free from land-based pollutants. In the nursery, coral fragments – either collected from viable stocks or salvaged from pieces of broken coral – may be attached to pedestals on blocks on the seafloor, hung on line nurseries that look like clothes lines, or placed in baskets suspended off the seafloor.

Vocabulary

Abiotic factors - The nonliving factors in an ecosystem.

Acroporid corals - The genus that includes staghorn and elkhorn corals; important branching corals often grown in nurseries.

Anthropogenic - Human caused.

Biodiversity - The variety of life on Earth, encompassing variation at all levels, from genes to species to ecosystems.

Biotic factors - The living factors in an ecosystem.

Coral bleaching - A stress response during which corals expel the zooxanthellae living inside their tissues.

Coral nursery - A site where corals are grown for the purpose of outplanting.

Coral trees - A tree-link structure tethered to the ocean floor and buoyed with a subsurface float; coral fragments are hung from the branches of the tree using monofilament line.

Ecosystem - A system of interactions between a community of organisms and their environment.

Ocean acidification - The lowering of seawater pH due to increased dissolving of carbon dioxide into seawater.

Outplanting - The process of planting coral fragments grown in nurseries back onto reefs.

Reef building or "hard" corals - Corals that secrete a calcium carbonate exoskeleton.

Substrate - The surface or material on, or from which, an organism lives, grows, or obtains its nourishment.

Floating freely in the water, the corals receive better water circulation, avoid being attacked by predators such as fireworms or snails, and generally survive at a higher rate. The rescued corals are generally cared for by biologists and volunteers who monitor their health and growth and keep algae, encrusting sponges, and tunicates at bay. The goal is to transplant nursery-reared corals back out on the reef to bolster existing coral colonies, to reseed reefs after major events, and to increase the likelihood of successful cross-fertilization during sexual reproduction.

Preparation

1. Download or open links to all digital materials.
2. Prepare teacher and student devices (e.g., laptop, computer/projector, handhelds, VR sets, etc.).
3. Preview digital and print materials.
4. Copy Exploring Coral Restoration document (one per student), Coral Reef Ecology Webquest (one per student), and Designing a Coral Nursery document (one per pair).

Procedure

Part 1 - Introduction to Coral Restoration

Time: 25 minutes

1. Set the stage by reviewing the natural and anthropogenic impacts on coral reefs and why coral restoration is important by sharing the Mission: Iconic Reefs video.
2. As an example of what is being done to restoral coral reefs, project *Explore the Blue: 360° Coral Restoration* video on screen. Demonstrate how to "look around": up, down, left, right. Explain that Florida Keys National Marine Sanctuary (FKNMS) was established in 1990 in response to concerns about declines in the health of local coral reef ecosystems. Display a map of the sanctuary. Explain that Acroporid coral, specifically staghorn and elkhorn coral, have been particularly vulnerable (share pictures of both). Ninety-seven percent of these corals have been lost in the last 50 years. Both species, along with others, were listed under the Endangered Species Act in 2012. These species are reef-building branching corals which provide much structural diversity to the reef and thus increase its biodiversity.
3. Have students preview the questions on the Exploring Coral Restoration document prior to watching the video. Give students time to watch and explore *Explore the Blue: 360° Coral Restoration* video. Encourage them to pause the video and "look around." Students can record their observations and responses while exploring the video or after they have explored.
4. Once students have completed their exploration, explain the procedure for an activity called a "chalkboard splash." On the classroom whiteboard(s), write the following headings: site, coral trees, materials, tools,

Photo: Bill Precht/NOAA

and tasks. Ask students to write one observation from their Exploring Coral Restoration document underneath each heading. If they find that another student has written an observation that they also have, they should put their initials next to it.

Part 2 - Conservation Decisions in Action: Designing a Coral Nursery

Coral Reef Ecology Webquest

Time: 20 minutes

1. Allow students to explore the coral reef ecosystem at Cheeca Rocks Sanctuary Preservation Area (360° image) in Florida Keys National Marine Sanctuary. Ask them to think about the biotic and abiotic factors that are present and to consider what makes Cheeca Rocks a good place for corals to grow.
2. Distribute the Coral Reef Ecology Webquest document. Review directions and expectations. Circulate to answer clarifying questions.
3. Debrief student research using a technique called "Mingle, Pair, Share." A summary of this strategy is below:
    a) Have students walk around the room as music plays in the background.
    b) Once music stops, students pair up with the person closest to them.
    c) On the teacher's signal, one partner shares his/her/their answer to the first question on the webquest. The other partner listens.
    d) Partners switch roles after a set period of time.
    e) After both partners speak, the process continues in order to address subsequent questions.

Coral Nursery Design

Time: 45 minutes

1. Distribute the Designing a Coral Nursery document. Inform students that they are acting as a NOAA biologist for Florida Keys National Marine Sanctuary. Watch the Restoring Coral Reefs video which gives an overview of coral nurseries.
2. Lead a discussion of the following: What is good about the coral tree design used in the video?
    a) How does it promote zooxanthellae to photosynthesize?
    b) How does it allow water flow?
    c) How does it account for water temperature and dissolved nutrients?
    d) Did you observe any other living things in the coral nursery that need to be considered?
3. Review the Restoration Guidelines created by NOAA's Office of National Marine Sanctuaries. Students should recognize that all coral nurseries must be permitted and pass a strict review process before being implemented. Students should take these criteria into consideration when designing their coral nursery.
4. Review directions and expectations. Circulate to answer clarifying questions as students work.
5. Have students solicit feedback on their designs using an activity called "The Carousel" described below. This debrief pertains to the Designing a Coral Nursery document.
    a) Have each pair respond to the prompt in box.
    b) Match each pair with another pair and have quartet switch papers and respond to the prompt in box 2.
    c) Switch grouping two more times using the same procedure in order to complete the prompts in boxes 3 and 4.
6. If time permits, watch the TedTalk by Dr. Kristen Marhaver, coral reef biologist at the Caribbean Marine Biological Institute.

Education Standards

Next Generation Science Standards	Supports NGSS Performance Expectation MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. Science and Engineering Practices: • Constructing Explanations and Designing Solutions Crosscutting Concepts: • Cause and Effect • Patterns • Stability and Change
Common Core State Standards	**Language Arts:** • Integration of Knowledge and Ideas: o CCSS.ELA-Literacy.RST.6-8.7 o CCSS.ELA-Literacy.RI.6.7 • Production and Distribution of Writing: o CCSS.ELA-Literacy.WHST.6-8.6 • Text Types and Purposes: o CCSS.ELA-Literacy.WHST.6-8.1
Ocean Literacy Principles	5. The ocean supports a great diversity of life and ecosystems. 6. The ocean and humans are inextricably interconnected.
Climate Change Literacy Principles	7. Climate change has consequences.

Links to Lesson Content

- *Explore the Blue: 360° Coral Restoration video*: https://sanctuaries.noaa.gov/vr/florida-keys/coral-restoration/
- Map of FKNMS: floridakeys.noaa.gov/fknms_map/sanctuaryboundarymap.pdf
- Cheeca Rocks Sanctuary Preservation Area: https://sanctuaries.noaa.gov/vr/florida-keys/cheeca-rocks.html
- Restoring Coral Reefs Video: https://oceantoday.noaa.gov/fullmoon-restoringcoralreefs/welcome.html
- Restoration Guidelines: floridakeys.noaa.gov/media/docs/20190605-guidance-on-coral-restoration-outplanting.pdf
- Dr. Kristen Marhaver Ted Talk: https://www.ted.com/talks/kristen_marhaver_how_we_re_growing_baby_corals_to_rebuild_reefs?language=en#t-81041
- Elkhorn Coral: https://www.fisheries.noaa.gov/species/elkhorn-coral
- Staghorn Coral: https://www.fisheries.noaa.gov/species/staghorn-coral

Additional Information

- Exploring Corals: https://floridakeys.noaa.gov/corals/welcome.html?s=explore
- Coral Reef Conservation program: https://coralreef.noaa.gov/
- Coral Restoration Foundation: https://www.coralrestoration.org

Photo: Ocean First Education

Alternative/Extension Ideas

- Students complete the worksheets in their journal/notebook.
- Students record their nursery designs in Google Docs.
- Students create an illustration (labeled drawing) of their nursery design, then, in small groups, revise and edit their designs.
- Students develop a 3D model of their nursery design using readily available materials. Students present their designs for critique and suggested improvements, implementing the suggestions as per the engineering design process. (https://www.nasa.gov/audience/foreducators/best/edp.htmlwww.nasa.gov/audience/foreducators/best/edp.html)
- In pairs or small groups, students write a persuasive argument for coral restoration from the perspective of: the coral, prey fish species, predatory fish species, a scuba diver, a local beach-front homeowner, and a local restaurant owner.
- Students create an infographic summarizing the importance of coral reefs, including the ecological and economic impacts.
- Review the interdisciplinary activities available from the Coral Restoration Foundation for more hands-on activities related to coral restoration. (https://www.coralrestoration.org/activity-packs)

Funding provided by the National Marine Sanctuary Foundation.

Exploring Coral Restoration

As you explore the *360° Coral Restoration* video, pay careful attention to details about the following topics. Record your observations as bullet-pointed phrases that could be understood by someone else. Record your observations in the table below.

Topic	Observations
What do you notice about the site of the coral nursery?	
What do you notice about the coral trees?	
What materials do you see being used in the nursery?	

What tools do you see being used in the nursery?	
What tasks are scientists and volunteers performing?	

Please record at least two questions you have about what you have observed.

1.

2.

Coral Reef Ecology Webquest

Introduction

The International Union for the Conservation of Nature monitors the status of global ecosystems and lists coral reefs as critically endangered. Over 50% of reefs have been lost in the last 30 years and many leading coral reef scientists predict that without significant conservation efforts coral reef ecosystems could be extinct as soon as 2050.

This assignment will help you to understand more about corals and what scientists need to consider when trying to conserve them.

Assignment

Use the following resource, https://floridakeys.noaa.gov/corals/welcome.html?s=explore, to explore the topics below. Please take notes and be prepared to discuss with a partner and report to the whole class.

Topics

1. Explain at least three ways people benefit from coral reef ecosystems.

2. Describe where coral reefs are found and the abiotic factors necessary for their survival.

3. How do corals eat?

4. Explain how coral bleaching and ocean acidification affect coral reefs.

5. Explain the life cycle of coral (including how they can reproduce) and how reefs are made. Make sure to explain the relationship between coral polyps and zooxanthellae.

Designing a Coral Nursery

Photo: Zach Ransom/Coral Restoration Foundation

Introduction

The National Oceanic and Atmospheric Administration (NOAA) is a government organization that studies the interplay between the world's ocean and atmosphere. Their mission is to understand and predict changes in climate, weather, ocean, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources. (You can learn more here: noaa.gov).

You are a NOAA biologist working in Florida Keys National Marine Sanctuary, https://coralreef.noaa.gov/.

You have been tasked with designing a coral nursery to repopulate staghorn coral onto the reefs of the Florida Keys. You have reviewed the permitting guidelines and have been granted the permits for your work.

Assignment - Nursery Planning Questions

Keeping the permitting guidelines in mind, work with your partner to answer the following questions. Record your answers as bullet point phrases in the space provided.

1. How will you determine the site for your nursery? List at least three factors you must consider for site location and explain your choices.

2. Describe the maintenance that will need to be performed in your nursery. Describe at least two maintenance tasks and explain why the completion of these tasks would be important.

3. Describe how you will track the health and growth of your corals.

4. Describe the structure you will use to grow your corals and how your corals will be attached to it. You must design something other than coral trees. What materials and tools will you need to build your structure?

5. Describe how you will choose which corals to collect for growth in the nursery. Explain your reasoning.

6. How will you choose a site to outplant your corals? Explain your reasoning.

7. On a piece of grid paper, illustrate the design of one of the structures you have designed for growing your coral.

The Carousel

1. Summarize the design of your coral structure and your reasoning.	2. Read your classmate's response. In this box, add another reason that would support your classmate's response.
3. Add an opposing argument. In this box, record a reason that might be used as an opposing argument to what is written in boxes #1 & #2.	4. Add your "two cents." Read what is written in the three boxes. Add your opinion and your reason for it in this box.

Activity Rubric

Activity Component	4 - Students Exceeds Assignment Expectations	3 - Students meet assignment expectations	2 - Students approach assignment expectations	1 - Students' work is below assignment expectations
Exploring Coral Restoration 360°	Students' observations were detailed and specific. Students recorded interesting questions about their observation.	Students' observations were detailed and specific. Students recorded plausible questions about their observations.	Students' observations need some details. Students questions need depth and detail.	Students' observations need many details. Student questions need much depth and detail.
Coral Reef Ecology Webquest	Research was completed thoughtfully. Students' bullet points were detailed and specific. Students' discussion was detailed and specific. Students included additional questions and/or contributed to the whole group discussion.	Research was completed thoughtfully. Students' bullet points were detailed and specific. Students' discussion was detailed and specific.	Research was completed. Students' bullet points need some details. Students' discussion needs some details.	Research was completed hastily. Students' bullet points need many details. Students' discussion needs many details.
Designing A Coral Nursery	Nursery planning questions are answered thoughtfully and specifically. Sketch of coral structure meets requirements. Students gave and received exceptionally thoughtful constructive feedback via carousel.	Nursery planning questions are answered thoughtfully and specifically. Sketch of coral structure meets requirements. Students gave and received thoughtful constructive feedback via carousel.	Nursery planning answers needs some detail. Sketch of coral structure meets most requirements. Students gave and received some thoughtful constructive feedback via carousel.	Nursery planning answers needs a lot of detail. Sketch of coral structure meets few requirements. Students gave and received little thoughtful constructive feedback via carousel.