COASTAL PROTECTION

CORAL RESILIENCE LAB

HAWAIʻI INSTITUTE OF MARINE BIOLOGY

GRADES 3-5

OBJECTIVE

Students will be able to understand the value of coral reefs and identify the role they play in protecting us and our coastlines from natural disasters and loss of property.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

This curriculum was developed in accordance with the NGSS. Next Generation Science Standards (NGSS):

3-LS4-3	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some can’t survive at all
3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of weather related hazards
3-LS4-4	Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide
4-ESS3-2	Generate and compare multiple solutions to reduce the impact of natural earth processes on humans

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA’s Bay Watershed Education Program (BWET)

Vocabulary

Endemic	Climate Change
Artificial Reef	Dredge
Sedimentation	Overfishing

Introduction

Coral reefs are very important to the ocean. They are home to many different types of plants and animals, and provide a number of services including food, shelter, protected areas for young, etc. Coral reefs help us on land by providing a physical barrier against waves and other natural disasters. In the US, coral reefs are found in Hawaiʻi and Florida. Researchers estimate that each kilometer of reef in Hawaiʻi provides around $10 million in flood protection[1].

Background

Corals help humans and marine animals in many ways. Nearly half a billion people around the world count on coral reefs for food, jobs, and protection. The shape of the reef itself has holes where ocean animals live and are protected. Because of this, corals can be referred to as the "apartment complexes" of the ocean. Coral reefs also have lots of different types of ocean animals. One out of four ocean plants and animals spend some part of their life on the reef.

This is also helpful for fishermen who are able to get food from off the reef. The coral reefs in the Papahānaumokuākea National Marine Monument

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

in the Northwest Hawaiian Islands alone supports over 7,000 species of marine organisms, ¼ of which are **endemic** and found nowhere else in the world[2]. Scientists can also do research to find new medicines from plants, animals, or bacteria living on coral reefs. People also sometimes have jobs related to coral reefs, such as dive tours, cruises, etc., and reefs are culturally significant, especially in Hawaiʻi. That being said, one of the most important things that coral reefs do is protect our coastline from storms, and the large waves and flooding that often accompany these storms.

All of these roles of coral reefs mean that they are very important for things living in the ocean as well as people living on land. The shape that the coral reefs make is so big that you can even see it from space. These shapes protect humans and houses on land from roughly 97% of wave energy[3,4], meaning that there will be much less property damage and erosion when large storms come. Having the coral reef as protection helps to stop this big wave energy and protect everything on shore. Around the world, 200 million[5] people depend on coral reefs for protection. Coral reefs in the United States alone provide nearly $1.8 billion in flood-risk benefits to property owners every year[6].

A 2021 study[7] in Hawaiʻi puts a dollar value on the reefs across Oʻahu for the amount of flood damage that reefs prevent from occuring every year. Each kilometer of reef studied provides over a million dollars in protection from damage, and across Oʻahu collectively valued at over $575 million. These reefs include:

South Shore (Diamond Head, Waikīkī, & Kakaʻako) at $154.3 million
East Honolulu (Maunalua Bay)- $78.4 million
Kailua (Lanikai to Mokapu) - $83.0 million
Waiʻanae - $92.4 million
ʻEwa - $77.5 million
Koʻolau Loa (Punaluʻu to Kahuku) - $62.0 million
North Shore (Pūpūkea) - $18.1 million

Curriculum Funded by NOAA’s Bay Watershed Education Program (BWET)

Waialua - $12.1 million

Artificial reefs are reef structures composed of non-natural or man-made materials such as sunken car bodies, concrete pipes, boats, etc. These can be helpful in restoring coral reef habitat as long as they are thought out and made out of the appropriate materials. Depending on the material that these structures are made of, the chemicals in the structure over time can break down and pollute the water, so it's important to make sure that artificial reefs are made out of materials like metal that don't break down over time. If designed correctly, they

have the ability to serve as one way of restoring reef habitat. Billions of dollars are being put towards building artificial reefs, as it provides habitat and protection for other organisms that might otherwise be lost. That being said, a better long-term option is to help make natural reef habitats as healthy as possible, which often provides better quality habitat for living things. The creation of artificial reefs is also much more costly than restoring natural reefs. The cost to restore a meter of natural reef is an average of $1,300, but an artificial reef costs $19,800 per meter to build on average[8]. Between the cost and the habitat provided by a natural reef, it is a much better goal to protect and restore the reefs that we already have.

Maunalua Bay

Maunalua Bay on Oʻahu is one area that is well known for having lots of coral and fish in the past. The Bay extends from the back side of Diamond Head by Black Point to Koko Head by Portlock. Sadly, as more people moved into the area, the ocean in Maunalua

*Photos provided by the Coral Resilience Lab; for more credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

Bay is not as healthy as it used to be. In fact, the fish population in Maunalua Bay has shrunk more than almost any other place in Hawaiʻi. This is partly because the fishpond that used to be there was turned into a big channel, and when that happened a lot of the coral and sand was **dredged** and used for other things. When they did this, all of the natural processes that kept soil in place and kept the bay healthy were removed. Soil ran into the water, and a lot of the coral that wasn't taken out was covered by sand and soil. The process of soil running into the water is called **sedimentation**, and when this happens the soil often washes over and covers anything near the shore. Because of this, a lot of the coral that didn't get taken out was covered by sand soil and was unable to survive. Efforts to restore the health of Maunalua Bay are underway by groups such as Mālama Maunalua, whose efforts are gradually restoring the health of the ecosystem.

Coral Reef Stressors

Unfortunately, there are some things that are harming coral reefs here in Hawaiʻi and around the globe. In Hawaiʻi reefs are being hurt because of the amount of trash, dirt, and other things that flow from the land into the sea and makes it unhealthy. In some places, people are **overfishing** so much that the number of fish on the reef is dropping, and boats and boat anchors sometimes hit the reef and damage it in that way. Around the world, a changing climate is making the ocean warmer too, and that's making it harder for coral to be healthy. The changing climate is already drastically decreasing the amount of live coral cover[9], with some areas of the world's coral formations decreasing by as much as 50% since 1950[10]. If not enough coral is alive, then not only does that hurt the other living things on the reef, it also means that the coast is less protected. Losing just the top meter of reef means that the cost of flood damages from storms would double[11]. If the reef isn't there to help stop waves and storms, then flooding and damage will happen more often.

Corals also grow really slowly. If you hold a fist up to your eye and open your fist so that you can just start to see light through it, that's about how much corals grow in a full year. Because corals grow so slowly, it's important that we do what we can to make sure that reefs stay healthy. We can do this by taking care of our reefs locally, and doing what we can to minimize the impacts of **climate change**.

As the climate continues to warm, researchers have found that for every 1.8 degrees Fahrenheit that ocean surface water temperatures increase above 82 degrees Fahrenheit, the number of extreme storms has gone up by roughly 21%[12]. If we take action and do what we can to protect coral reefs, we and all the people that come after us will be able to enjoy the beauty of coral reefs and take advantage of all the things they do to help us.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

Activity Overview

Students will be guided through two activities that show how different forms of wave barriers protect the coast. In one activity, they will build their own coastline. Students will make hypotheses, record what they see, and decide which type of barrier is best at protecting the coastline.

Materials

- Tubs or pans
- Sand or another type of sediment
- Small coral bits, shells, clay, or rocks
  - Keep in mind: *Taking of sand, dead coral, and coral rubble is prohibited statewide in Hawaiʻi by statute HRS 171-58.5 and 205A-44*
- Water
- Blue food dye (optional)
- Tennis balls or other light balls
- Materials that can be used as obstacles (ex. Chairs, tables, stools, etc.)

Teacher Prep

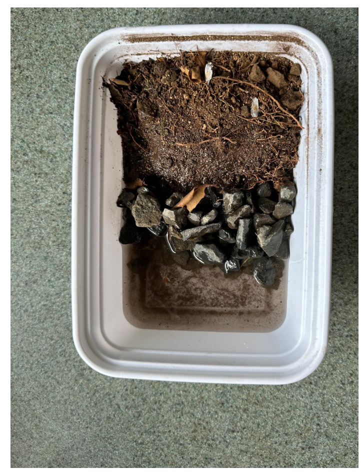
- Gather materials needed for each activity
- Make sure there is a large cleared area to play the life-size game
- Print out the student worksheets

Procedure/Instructions

Part 1: Build-Your-Own Coastline Explain to students that they will be making a model of a beach that will show what waves do when they come into shore. Have them observe and be able to explain how corals can decrease wave activity. Students will record what they think will happen, what they see, and conclusions about why corals are important to us on land. This activity is adapted from the Central Caribbean Marine Institute.

1. Instruct students they will work in pairs or small groups.
2. Pass out materials (containers, sand, coral /rocks/ clay) and worksheets to students.
3. Students will fill one half of the container with sand, going about halfway up the container. Fill the containers with water so it hits just under the sand. The sand will represent the coastline, and the water is the ocean.

4. Before adding any barriers, instruct the students to make waves in their container by rocking it back and forth gently, so the water starts to move to the coast. This will represent waves. Instruct the students to record their observations. Specifically, instruct them to take note of whether or not the sand is moving.



5. Students will start to add barriers (coral or clay) to their containers. This will represent coral reefs.
6. Instruct students to make different kinds of barriers and record their observations. Smaller reef, larger reef, reef close to “shore”, reef farther away from “shore.” Repeat the steps to make waves in their containers.

Part 2: When Waves Come Rolling In

This interactive life-size game will allow students to create their own obstacles and choose how they want to protect their classmates on land.

1. Clear out a large space where students can play–either inside or outside–and have students split into two groups.
2. Explain to students that one side of the room will be the coastline, and one

side will be the ocean.

3. Students in group 1 will be given tennis balls or other light balls to represent waves. Instruct this group to stay on one side of the room.
4. Students in group 2 will start to create obstacles with things around the classroom (ex. Chairs, tables, books, stools, backpacks etc.) to represent coral reefs.
5. Have students gradually add obstacles throughout the course of the game. As the obstacles start to increase, have students make conclusions about how the structure of a coral reef can impact the wave energy coming onto land.
6. The game will start with no obstacles. Group One will begin to lightly roll their balls across the space so that the balls reach the “coastline.”
7. Instruct Group Two to start adding obstacles between the coastline and the ocean small amounts at a time. Group One continues to roll balls across the floor as this is done.
8. As obstacles are added, fewer balls will make it across the ocean to the coastline.
9. Ask students to hypothesize what is happening and how this applies to coral reefs in Hawaiʻi. Ask what they think will happen if coral reefs are degraded (ie if obstacles are taken away). Have them test this hypothesis.
10. Have groups switch roles and play again.

Created by Madeleine Sherman, Hawaii Institute of Marine Biology, 2022

Contributions from Maile Villablanca, Coral Resilience Lab, 2022; Hayley Luke, Coral

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link
Curriculum Funded by NOAA’s Bay Watershed Education Program (BWET)

Resilience Lab, 2022

Coastal Protections:

Build Your Own Coastline

Student Worksheet

Instructions:

1. Bank sand up in one half of the container. Make sure you can still see the bottom of the container in the half without the sand. Sand should come about halfway up the side
2. Fill the containers with water so it hits just under the sand. In this demonstration, the sand represents the coastline, and the water represents the ocean.
3. Make waves in your container by rocking it back and forth gently, so the water starts to move to the coast. These are similar to ocean waves. Observe and record observations of if and how the sand is moving.
4. Add barriers to the container (corals or clay). These play the role of the coral reef.
5. Make waves in your container and record your observations.
6. Experiment with how the shape and location of the barrier (is it close or far from the shoreline? Is it tall or short? Big or little?).
7. Record your observations and pay attention to which structures are the most effective at stopping wave energy.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

Build Your Own Coastline

Student Worksheet

1. Get materials from your teacher and follow the instructions below.
2. Fill out the chart below with what you see in each coastline model.

Predict what you think will happen			
	Do the waves reach the shoreline?	How do waves affect the beach?	Notes
Container with no coral reef			
Container with big coral reef			
Container with small coral reef			

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

Observe and Record what happened			
	Do the waves reach the shoreline?	How do waves affect the beach?	Notes
Container with no coral reef			
Container with small coral reef			
Container with large coral reef			

Additional observations:

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA’s Bay Watershed Education Program (BWET)

Dive in deeper…

1. What happened when waves hit your beach and there was no coral there?

2. Why are reefs important for protecting coastlines?

3. What happens to people and houses located on the coast if reefs aren't there?

4. What would happen to **coastlines** if the coral reefs were to get smaller?

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

5. What happens to the **energy** in a wave when it hits a coral reef?

6. Why do you think coral reefs are better at protecting us on land as compared to other types of barriers?

7. Write down some ways we can protect corals and protect ourselves.

8. What is something that makes corals more or less able to survive?

9. Name one benefit of making sure that our coral reefs stay healthy.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)

Sources Cited

1. Reguero, Borja G., et al. “The Value of Us Coral Reefs for Flood Risk Reduction.” *Nature Sustainability*, vol. 4, no. 8, 2021, pp. 688–698., https://doi.org/10.1038/s41893-021-00706-6.
2. PMNM Webmaster. “Aloha! Welcome to Papahānaumokuākea Marine National Monument – Where Nature and Culture Are One.” *Papahānaumokuākea Marine National Monument*, National Ocean Service; Office of National Marine Sanctuaries; National Oceanic and Atmospheric Administration, 30 July 2020, https://www.papahanaumokuakea.gov/about/.
3. Nuwer, Rachel. “Coral Reefs Absorb 97 Percent of the Energy from Waves Headed toward Shore.” *Smithsonian.com*, Smithsonian Institution, 15 May 2014, https://www.smithsonianmag.com/smart-news/coral-reefs-absorb-almost-all-energy-crashing-waves-headed-toward-shore-180951462/.
4. The Coral Reef Alliance. “Coastal Protection.” *Coral Reef Alliance*, Coral Reef Alliance, 1 Sept. 2021, https://coral.org/en/coral-reefs-101/why-care-about-reefs/coastal-protection/.
5. The Coral Reef Alliance. “Coastal Protection.” *Coral Reef Alliance*, Coral Reef Alliance, 1 Sept. 2021, https://coral.org/en/coral-reefs-101/why-care-about-reefs/coastal-protection/.
6. Beck, Michael. “Coral Reefs Provide Flood Protection Worth $1.8 Billion Every Year – It's Time to Protect Them.” *The Conversation*, The Conversation US, Inc, 13 Sept. 2022, https://theconversation.com/coral-reefs-provide-flood-protection-worth-1-8-billion-every-year-its-time-to-protect-them-116636.
7. Storlazzi, C.D., Reguero, B.G., Cole, A.D., Lowe, E., Shope, J.B., Gibbs, A.E., Nickel, B.A., McCall, R.T., van Dongeren, A.R., and Beck, M.W., 2019, Rigorously valuing the role of U.S. coral reefs in coastal hazard risk reduction: U.S. Geological Survey Open-File Report 2019–1027, 42 p., https://doi.org/10.3133/ofr20191027.
8. Nuwer, Rachel. “Coral Reefs Absorb 97 Percent of the Energy from Waves Headed toward Shore.” *Smithsonian.com*, Smithsonian Institution, 15 May 2014, https://www.smithsonianmag.com/smart-news/coral-reefs-absorb-almost-all-energy-crashing-waves-headed-toward-shore-180951462/.
9. Hughes, Terry P., et al. “Spatial and Temporal Patterns of Mass Bleaching of Corals in the Anthropocene.” *Science*, vol. 359, no. 6371, 2018, pp. 80–83., https://doi.org/10.1126/science.aan8048.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA’s Bay Watershed Education Program (BWET)

10. Ashworth, James. "Over Half of Coral Reef Cover across the World Has Been Lost since 1950." *Natural History Museum*, The Trustees of the Natural History Museum , 26 Sept. 2021, https://www.nhm.ac.uk/discover/news/2021/september/over-half-of-coral-reef-cover-lost-since-1950.html.
11. Beck, Michael W., et al. "The Global Flood Protection Savings Provided by Coral Reefs." *Nature Communications*, vol. 9, no. 1, 2018, https://doi.org/10.1038/s41467-018-04568-z.
12. "Warming Seas May Increase Frequency of Extreme Storms – Climate Change: Vital Signs of the Planet." *NASA*, NASA, 23 July 2019, https://climate.nasa.gov/news/2837/warming-seas-may-increase-frequency-of-extreme-storms/.

*Photos provided by the Coral Resilience Lab; for more information on photos, and photo credits, please consult this link

Curriculum Funded by NOAA's Bay Watershed Education Program (BWET)