CORAL BLEACHING

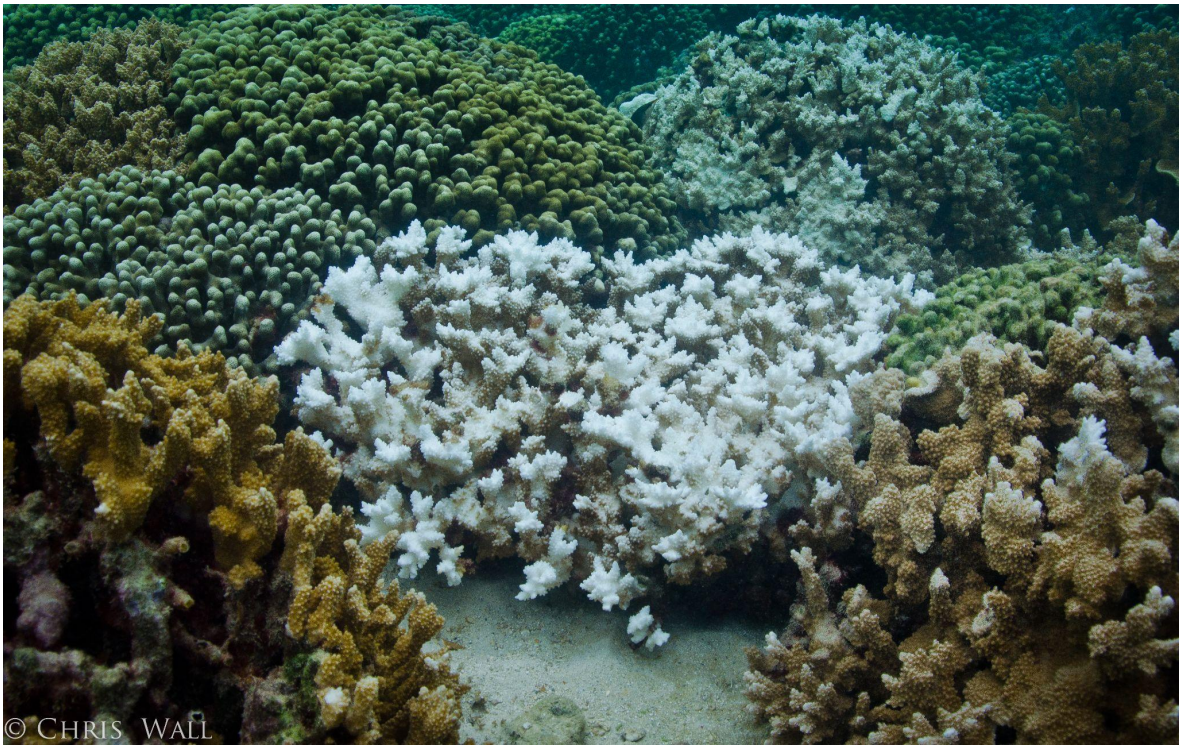
CORAL RESILIENCE LAB

HAWAIʻI INSTITUTE OF MARINE BIOLOGY

Gr 3-5 ELEMENTARY LEVEL

OBJECTIVE

This lesson plan, coupled with a hands-on activity, seeks to bring a tangible visualization of coral bleaching to students. This will allow students to better understand the phenomenon of global climate change, and how it can impact ecosystems.



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

3-LS3-1	Analyze and interpret data to provide evidence that plants and animals have traits inherited from their parents, and that variation of these traits exists in a group of similar organisms
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
4LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction
5-ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact
5-PS3-1	Use models to describe that energy in animals' food (used for boy repair, growth, motion, and to maintain body warmth) was once energy from the sun

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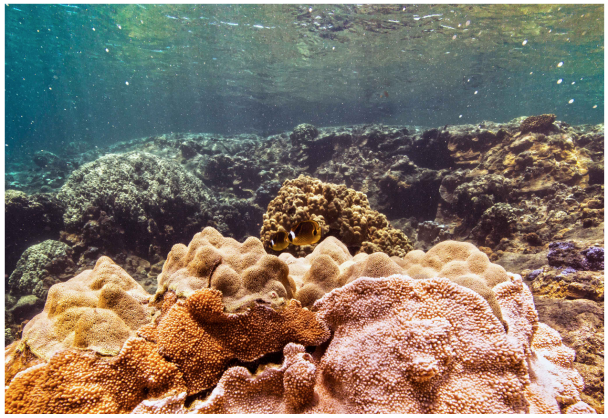
Vocabulary

Climate Change	Coral Bleaching
Cnidarians	Carbon Sink
Nematocysts	Resilience
Symbiodiniaceae (zooxanthellae)	Koʻa Card

Introduction



Coral bleaching is caused by a number of things that can harm the environment, like high levels of sand in the water, increases in light, and excess freshwater. That being said, the primary reason that corals bleach is a rise in sea temperature. Global temperatures have increased as a result of human caused **climate change**. The ocean absorbs 90% of this heat[1], meaning that ocean animals get exposed to warmer temperatures. Coral bleaching is becoming more frequent and severe, leading to an increase in the number of corals that die. Half of the global coral reefs have already been lost[2], and in the next 30 years, we may find that less than 1/10 of the world's corals have been left unimpacted by bleaching[3].

Background

Corals are animals that are related to sea anemones and jellyfish, all of which belong to the phylum Cnidaria. These **Cnidarians** all have stinging cells called **nematocysts** that help to protect the coral, and help it gather food from its environment. The coral reef not only supports life in the ocean, but helps to

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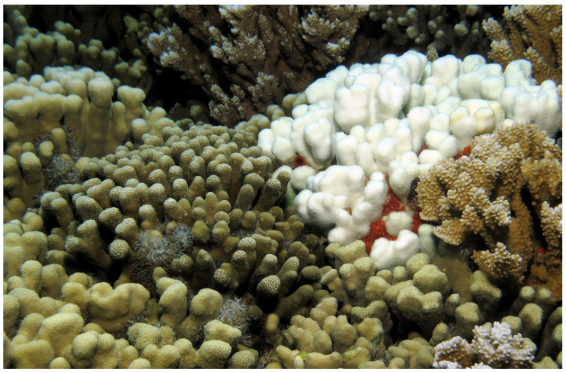
provide jobs, coastal protection, food, and medicine to millions of people worldwide. Corals are one of the main foundation species in our oceans. They are a keystone species, meaning that if coral disappeared from the ecosystem, the whole ecosystem as we know it now would fall apart. As such, the coral reefs give a lot of support to life in the oceans and contribute a great deal to surrounding ecosystems. Fish, invertebrates, algae, and other organisms often begin life on a coral reef, and 1 out of 4 ocean animals spend some part of their life on the reef. Coral reefs do not only help marine habitats. On the coast, coral reefs protect coastlines by calming down wave energy before it hits the shore, and housing algae that contributes to the global oxygen supply.

The animal that is coral has a symbiotic relationship with tiny plant-like organisms that live inside of them. These organisms are called ***Symbiodiniaceae*** or **zooxanthellae**. The zooxanthellae get energy from the sun and provide food for the coral animal, and in return the coral provides shelter and nutrition for the zooxanthellae. The zooxanthellae are also what gives the coral its color. When temperatures get too warm, the zooxanthellae don't photosynthesize efficiently. As a result, the coral host becomes stressed and expels the algal symbionts and appears white in color, leaving the coral polyp's transparent tissues over its white skeleton. This phenomenon is called coral bleaching.



The cause of warming ocean temperatures is human-caused climate change. Global temperatures have rapidly increased since 1880, and the year 2020 and 2016 are tied for the warmest years on record[4]. In the past 50 years, 90% of this warming has occurred in the oceans, increasing an average of .14 degrees fahrenheit per decade since 1880 and an average of .32 degrees Fahrenheit per decade since 1981[5]. This is concerning because it takes much more energy to warm up water than it does to warm up air. Oceans are big– over 7/10ths of the

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Earth is made up of ocean, so any time the ocean gets warmer and then stays warmer, it is cause for worry just because it takes so much energy to heat up that amount of water.

In addition to global climate change, the level of atmospheric carbon dioxide is higher today than it has been at any time in the last 800,000 years[6]. This is also a result of humans' activities, including the burning of gas as a source of power. When we burn this gas it releases carbon dioxide, which is a large contributor to climate change. This means that the more CO_2 that gets released, the more our climate will change. The ocean acts as a **carbon sink**– a place that holds carbon dioxide where it doesn't change the temperature of the air– and stores roughly 25% of carbon dioxide that would otherwise be in the atmosphere[7]. Because the ocean is storing so much carbon dioxide, it is significantly slowing down how fast the climate is changing.

While the ocean goes through normal warming and cooling cycles, there have been 3 major bleaching events caused by significant warming in the last 6 years, with severe back-to-back bleaching from 2014 to 2015[8]. This bleaching event resulted in 32% of corals around O'ahu bleaching, and over half of all corals being bleached in some parts of Hawai'i[9]. Corals are able to tolerate an increase in temperature of 1-2 degrees Celsius just due to the fact that water temperatures normally increase in summer. But the combination of global temperature increases and high summer temperatures makes corals particularly at risk. While corals can survive a bleaching event, extended and repeated exposure to high temperatures will typically result in the death of the coral. These extended bleaching events also make corals more likely to get sick since bleaching makes them more vulnerable to infections. As the oceans continue to warm, bleaching events are predicted to happen more frequently and more intensely within the

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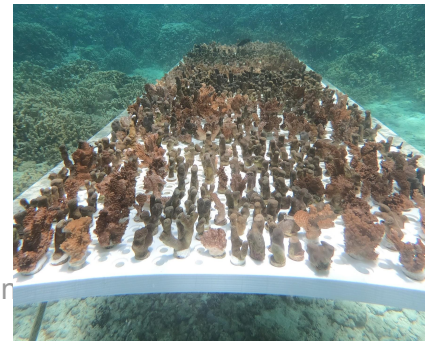
coming decades.

Corals in Hawaiʻi also grow slowly, making it difficult for corals to be able to adapt to change quickly. If you hold a fist over your eye, and open it enough that you can just barely see light poking through, that's how much a coral colony grows in a full year. However, depending on the species of coral and the surrounding environment, corals can respond differently during an ocean warming event that might make some corals bleach. For example, one coral might bleach and die, while another individual coral on the same reef might not. The corals that are better able to survive a bleaching event are called super corals. The name "super coral" is used to define corals that have survived a period of ocean warming that is the cause of a bleaching event. Super corals exhibit unique traits that make them very important to study, especially when it comes to efforts to restore the reef. Corals can also be considered "super corals" if they bleached during an ocean warming event, but were then able to recover and survive in the future. In order for coral restoration efforts to truly make a difference, the corals that researchers put back out on the reef need to be the most thermally tolerant possible, which is why researchers are focusing on these corals specifically for coral restoration.

Coral reef biologists are researching new ways to tap into the power of these specific corals. Biologists have found genetic clues that link super corals and zooxanthellae that are better able to survive in warmer temperatures. Some species of zooxanthellae have adapted to rising surface ocean temperatures. Different species of corals host different species of their algal symbionts. Certain corals have been observed to shift the algae in their tissues and utilize the species that are more heat-tolerant. However, no coral is resilient to every stressor, which is why it is crucial not only to think of our impact on a global scale, but also locally.

The Coral Resilience Lab at the Hawaiʻi Institute of Marine Biology is taking advantage of these bleaching resistant corals in a new restoration project called Restore with Resilience. The word "**resilience**" means



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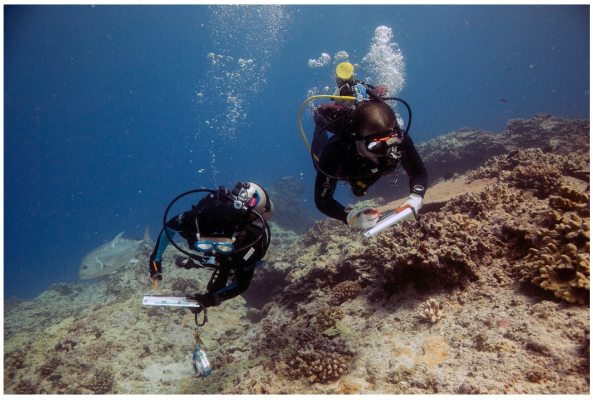
“toughness” or the ability to recover and overcome challenges. This Restore with Resilience project is the first of its kind on Oʻahu. It studies how humans can help corals better adapt to climate change, by putting the corals that are best able to live in higher ocean temperatures back on the reef. Studies are also done on the genetics of the coral and of the coral’s zooxanthellae to examine why a certain coral is resistant to bleaching and another one is not. One of the Restore with Resilience study sites we work with is in Maunalua Bay. Partnered with Mālama Maunalua and other local organizations and government agencies, it is the very first community-based coral restoration project in Hawaiʻi. Members of the community assist with the research, and process the corals for outplanting.

Researchers at HIMB from the Coral Reef Ecology Lab have developed the ***Koʻa Card*** to monitor coral bleaching in Hawaiʻi. These Koʻa Cards use specific colors to help identify coral health, and are used to help track changes in coral color– and therefore coral health– over time. Using these cards, members of the community, including students, educators, visitors, and everyone in between, are able to assist with reporting coral bleaching for scientific data. For instructions on how to use the Koʻa Card and where to find yours, you can visit https://coralreefecologylab.com/hawaiian-koa-card/.



Aside from scientists, there are plenty of ways for people to help save coral reefs. Since climate change is the biggest threat, the best step we can take is to make our reliance on fossil fuels like gas as small as possible. That could include finding ways to get around other than a gas-powered car, avoiding single-use plastic, reducing your dairy and meat consumption, eating and shopping locally, and supporting businesses that promote sustainability. Most importantly, it’s good to educate yourself and others on corals and the threats they face.

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Bringing awareness to an issue can help make the biggest difference!

Activity Overview

This activity will give students a better understanding of how ocean warming events and other stressors affect the health of corals, and will demonstrate corals that do and do not bleach. As a parallel, students will be able to see the physical change that the animal undergoes when exposed to a warming event. Teachers: be able to answer the following questions and review with students:

What is a coral and what happens when coral bleaches?

What causes coral bleaching?

Why are some corals better able to survive in warmer water than othersl?

Materials

Coral Bleaching Kit (available from the UH Stem Pre-Academy)

- "Bleached" and "non-bleached" painted coral pieces (count before and after activity)
    - Note: Per Hawai'i State Law the *Taking of sand, dead coral, and coral rubble is prohibited statewide in Hawai'i by statute HRS 171-58.5 and 205A-44*
    - If real coral skeletons are not available to you, use rocks, clay, 3D printed corals, etc in their place. Paint these pieces with thermochromic paint (bleaching corals), and conventional paint (super corals)
- Two large heat-safe glass beakers marked 'AMBIENT' and 'HOT'
- One set of metal tongs (used to remove coral pieces from 'HOT' water, use caution when doing so)

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- Folder containing laminated images and helpful teaching visuals
- Kettle with corresponding hot pad (please exclude if personal kettle was used)
- Optional: Thermometer

Additional materials necessary for Coral Bleaching Activity

- Computer and projector (connection to internet)
- Thumb drive containing images and video footage from HIMB and other sources.
- Coral ID Guide

Teacher Prep

- Familiarize yourself with the coral bleaching student worksheet and make copies to pass out to students
- Lay out materials for coral bleaching activity
- If you will be showing the documentary *Chasing Coral* as supplemental material, you can access it through Netflix and have it prepared for showing

Procedure/Instructions

Part 1: Introduction to Coral Bleaching

1. Meet the Researchers and Scientists at the Hawaiʻi Institute of Marine Biology through "What is a Coral Biologist?" https://www.youtube.com/watch?v=spUxDz778Yg
2. To gain a better understanding about the importance of our coral reefs and how coral bleaching has become a marine epidemic, the Netflix documentary, *Chasing Coral* is a great place to start for teachers and students alike. The documentary features coral biologists from the Hawaii Institute of Marine Biology.

Part 2: Hands-on Coral Bleaching Activity

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1. Pass out the student activity worksheet
2. Prepare the hot water using the kettle and hot pad, make sure to obtain a temperature of around 31-35 degrees Celsius.
3. Fill the ‘ambient’ beaker with cool water.
4. Take painted coral skeletons out of the kit and arrange them randomly on the table, making sure to mix up non-bleached and bleached corals. Before instruction begins, make sure you are familiar with the procedure yourself. (Note: Refrain from letting students handle the hot water and the glass beakers)
5. Have students pick one coral at random and place it in the ‘ambient' sea water (The coral should not change color).
6. Instruct the student to remove the coral piece from the ‘ambient’ water and place it in the ‘hot’ water. If the coral turns white, it has experienced bleaching. If not, this coral is a “super coral”. CAUTION: When doing this step, have students use the tongs when removing the coral piece, the water will be very hot.
7. Have students observe what they see, and record their findings on the data sheet.
8. Have students remove the ‘bleached’ coral piece from the hot water and place it back into the ‘ambient’ sea water. This will help simulate the ability of corals to recover from bleaching. Call attention to the fact that these corals do not quickly regain their color after bleaching. Link this to our changing climate.
9. Utilize the laminated pictures and digital tools to show how live corals and bleached corals look in the wild.

Optional Alteration:

1. Pass out the student activity worksheet
2. Prepare the hot water using the kettle and hot pad, make sure to obtain a temperature of around 31-35 degrees Celsius.
3. Fill the ‘ambient’ beaker with cool water.
4. Take painted coral skeletons out of the kit and arrange them randomly on the table, making sure to mix up non-bleached and bleached corals. Before instruction begins, make sure you are familiar with the procedure yourself. (Note: Refrain from letting students handle the hot water and the glass beakers)
5. Have students pick one coral at random and place it in the ‘ambient' sea water (The coral should not change color).
6. Using the thermometer, have students record the temperature of the water

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(quantitative data) and color of the coral (qualitative data) in the data sheet
7. Have them slowly add a fixed amount of hot water to the beaker, recording the new water temperature and examining the coral for any color change after each addition of warm water
8. Continue with this process until the corals have bleached
9. Have them analyze the data and draw conclusions about ocean temperatures, typical corals, thermally resilient corals, and reef restoration
10. Have students graph their results

Commonly Asked Questions

Can bleached coral recover from bleaching?

> *Answer: Some corals are able to recover from bleaching events, however, ocean warming events are happening almost yearly and some corals will not be able to recover quickly enough. When coral bleaches it directs all of its energy to survival through manual feeding using their tentacles. This coral will hardly grow or reproduce and will likely die. Research has also shown that after coral bleaches it sometimes has the ability to take up symbionts from the surrounding environment, but it is much easier for a coral to do this if the ocean temperature has decreased to a comfortable level*

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Edited by Madeleine Sherman, Coral Resilience Lab, 2022; Maile Villablanca, Coral Resilience Lab, 2022

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Coral Bleaching Activity

Student Worksheet

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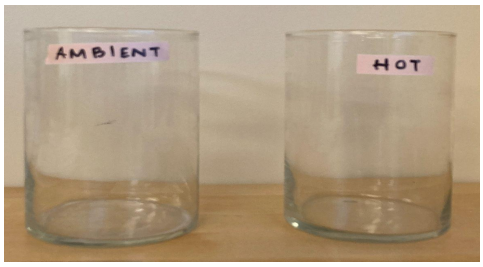
1. Obtain 5-10 coral pieces from your teacher
2. Fill out the chart below by testing each coral piece in the 'Hot' water beaker and determine if the coral has bleached or not. If applicable, make sure to note which species you are testing



Tag #	Coral Species	Bleaching (Yes/No)

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3. Compare your results with fellow classmates to see if any observations overlapped.

4. Design a scientific hypothesis that could explain why these corals are reacting the way they are.

Answer the following questions based on what you have learned from your teacher, the Coral Bleaching Activity, and any alternate media.

1. What is coral and why is it important to marine ecosystems?

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2. Where does the coral animal get its food? Where does the coral's zooxanthellae get its food?

3. Describe what happens when coral bleaches. Why does coral bleach?

4. What happens to a coral's zooxanthellae when a coral bleaches?

5. If coral bleaches can it recover? What happens after coral bleaches?

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6. What happens to the reef and the organisms on it if the corals are unable to recover from a bleaching event?

7. How are increases in human population and per-person consumption of natural resources impacting Earth's oceans?

8. Why do we think some corals are "super corals" and others are not? What do you think will happen to the number of these corals in an area as the ocean continues to warm?

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9. What will happen to the corals that are not super corals as the ocean continues to warm?

10. On a global and individual scale, is there anything that we can do to prevent ocean warming and widespread coral bleaching?

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