EDUCATOR GUIDE

HIDDEN PACIFIC

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Edited by Karlisa Callwood, Ph.D.

Hidden Pacific is produced by Tandem Stills + Motion,
in cooperation with the U.S. Fish & Wildlife Service.

Hidden Pacific is distributed by Giant Screen Films.

www.hiddenpacific.com #hiddenpacific #allmonumentsforall

About the Film

On the far reaches of the Pacific Ocean, blue-green islands, atolls, and coral reefs are thriving with a dizzying array of wildlife and tropical beauty, largely untouched by humans and currently protected as marine national monuments. *Hidden Pacific* will bring viewers to never-before-seen footage of these remarkable places, sharing the splendor of such pristine environments and their important role in safeguarding our planet.

Hidden Pacific features Palmyra Atoll, within the Pacific Remote Islands Marine National Monument, Midway Atoll, part of Papahānaumokuākea Marine National Monument, recently expanded by President Barack Obama in 2016, and Rose Atoll Marine National Monument, in American Samoa.

The film's breathtaking footage of these faraway islands will leave audiences with a deep-felt appreciation for these extraordinary places and the beauty of nature left untouched by civilization. The storied histories of these atolls—from the WWII Pacific Theater to their present environmental recovery and ecological research initiatives—provide the platform from which the film explores a diversity of science and human-interest stories.

Hidden Pacific seeks to educate the public about the critical role these marine monuments play in the face of environmental threats such as climate change, global warming, rising sea levels, ocean acidification, overfishing, and plastics pollution. Changes to current marine national monument protections could forever alter the delicate balance of these pristine marine ecosystems and the overall health of the planet.

About the Educator Guide

Hidden Pacific provides an ideal platform to discuss important concepts focused on marine ecosystem interactions. Key areas covered in the guide include:

› History of marine national monuments in the Pacific Ocean.

› Atoll formation and coral reef communities.

› Wildlife in the marine national monuments.

› Human impacts.

This guide is designed primarily for students in grades 2–8.

Each section of this guide includes:

› Alignment to Next Generation Science Standards.

› Background information on the section topic.

› Objectives.

› A materials list and directions for any setup necessary for the lesson.

› A detailed lesson procedure.

Photographer and filmmaker Ian Shive on location at the Wake Atoll National Wildlife Refuge.

Image courtesy of *Hidden Pacific*

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View of Papahānaumokuākea Marine National Monument, located in the northwest Hawaiian Islands, though not part of the state of Hawaii.

Image courtesy of *Hidden Pacific*

MARINE NATIONAL MONUMENTS

Overview: Students learn about the islands and atolls that are part of the marine national monuments in the Pacific Ocean and research the history of the islands, as well as the history and reason for the creation of the marine national monument system.

Grade Level: 2nd–5th grade

Next Generation Science Standards:

› **2-LS4-1:** Make observations of plants and animals to compare the diversity of life in different habitats.

› **3-LS4-3:** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

› **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.

› **5-ESS3-1:** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Objectives:

Students will be able to:

› Research the history of the marine national monuments (MNMs).

› List characteristics that define a marine national monument.

› Identify major groups of organisms living in and protected by the MNMs.

› Discuss conversation issues and human interactions that threaten organisms living with MNMs.

› Compare and contrast the four MNMs.

› Create a conservation poster that communicates their findings.

Time: 2 hours

Background Information:

Marine national monuments are a type of marine protected area that are designated to protect and conserve some of the last remaining pristine oceanic ecosystems. There are currently four marine national monuments in the Pacific Ocean: Papahānaumokuākea Marine National Monument, the Mariana Trench Marine National Monument, Rose Atoll Marine National Monument, and the Pacific Remote Islands Marine National Monument. The film *Hidden Pacific* features all of the marine national monuments with the exception of the Mariana Trench MNM.

The monuments were created to protect the abundant coral, fish, and seabird populations in the respective areas, as well as to facilitate exploration and scientific research and to promote public education about their value. Their establishment, as monuments, provides an opportunity to protect areas high in biodiversity, while also preserving and amplifying their scientific, cultural, and aesthetic values.

The Pacific Remote Islands Marine National Monument (PRIMNM) is one of the largest marine conservation areas in the world, ranging from Wake Atoll in the northwest to Jarvis Island in the southeast. The monument, comprised of seven national wildlife refuges, is home to a large number of terrestrial and marine organisms that use the islands and the surrounding shallow areas to rest, feed, mate, nest, and give birth to their offspring.

PRIMNM represents one of the last frontiers and havens for wildlife. It consists of seven atolls and islands: Howland, Baker, and Jarvis Islands, Wake, Palmyra, and Johnston Atolls, and Kingman Reef. Because it is so far from human population centers, the islands have a diverse collection of seabird, shorebird, and coral reef protected areas on the planet. These areas represent the last refuge for a large collection of threatened and endangered organisms that are rapidly vanishing or have already vanished from other parts of the world.

PRIMNM was created by a presidential proclamation on January 6, 2009 to protect some of the most pristine coral reef ecosystems in the world. A second presidential proclamation on September 25, 2014 turned PRIMNM into the largest marine reserve in the world by extending its boundaries; the enlarged monument is now about 490,000 square miles, larger than all the terrestrial national parks combined!

Papahānaumokuākea Marine National Monument was established in June 2006 and expanded in 2016. It is comprised of several previously existing federal conservation areas including the Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve, Midway Atoll National Wildlife Refuge, Hawaiian Islands National Wildlife Refuge, Northwestern Hawaiian Islands Marine Refuge, State Seabird Sanctuary at Kure Atoll, and the Battle of Midway National Memorial. On July 30, 2010, Papahānaumokuākea was designated as a World Heritage Site, further demonstrating the commitment of the United States and the state of Hawaii to conserve this important place.

Rose Atoll Marine National Monument was established in 2009. It is approximately 130 nautical miles east-southeast of American Samoa. It is the easternmost Samoan island and the southernmost point of the United States.

Activity 1: Timeline of the Marine National Monuments

Time: 60 minutes

Materials:

- ☐ Copies of resource worksheet (20)
- ☐ 3–4 feet of butcher paper
- ☐ 5x7 index cards (100)
- ☐ Markers, crayons, or other art materials
- ☐ String
- ☐ Thumb tacks
- ☐ Single-hole hole puncher

Setup:

1. Create a resource worksheet using the following links and any other resources you find:
   a. NOAA Fisheries: Pacific Remote Islands Marine National Monument
   http://www.fpir.noaa.gov/MNM/mnm_prias.html
   b. Presidential Proclamation—Pacific Remote Islands Marine National Monument Expansion
   http://www.whitehouse.gov/the-press-office/2014/09/25/presidential-proclamation-pacific-remote-islands-marine-national-monumen
   c. NOAA Fisheries: Pacific Islands Regional Office. Marine National Monument Program
   http://www.fpir.noaa.gov/MNM/mnm_index.html
   d. U.S. Fish and Wildlife Service (2012). Pacific Remote Islands Marine National Monument Fact Sheet
   https://www.fws.gov/uploadedFiles/Region_1/NWRS/Zone_1/Pacific_Remote_Islands_Marine_National_Monument/Documents/PRIMNM%20brief(2).pdf

2. Use the butcher paper to create a visual timeline that identifies the time periods listed below and hang it in the room. Leave a good amount of space between each time period.
   a. Pre-1900s
   b. 1900–1960
   c. 1961–1990
   d. 1991–2010
   e. 2011–present

Procedure:

1. Ask students to share some of the information they learned about the marine national monuments (MNM) featured in the *Hidden Pacific* documentary. Was there any information that was surprising?

2. Explain to the students that the MNMs are special places, because they provide safe habitats for millions of seabirds, shorebirds, marine mammals, fish, coral species, and more. The MNMs have a very long history that students can spend some time exploring.

3. Break students into five groups and assign each group a time period.

   a. Pre-1900s

   b. 1900–1960

   c. 1961–1990

   d. 1991–2010

   e. 2011–present

4. Give each student a resource sheet and instruct them to work in their groups to research the areas and history of the marine national monuments and 4–5 interesting facts from their assigned time period.

   a. For each fact, the students should use an index card and describe the fact on one side.

   b. On the other side of the card, they will draw a picture of the fact.

   c. Once the card is completed, they can punch a hole at the top of the card, tie on the string, and use a tack to hang it on the timeline.

5. Once each group has completed their cards, have them present their facts and why they think it is important to MNM history.

Activity 2: Marine National Monument Conservation Poster

Time: 60 minutes

Materials:

- ☐ Poster board (10)
- ☐ Copies of the Marine National Monument Organizer (20)—see below
- ☐ Map of the Pacific Remote Islands Marine National Monument
- ☐ Art materials

Setup: None.

Procedure:

1. If your students did activity 1, ask them to think back to the MNM timeline project. If students didn't do activity 1, skip questions 1a and 1b, and review the creation of the marine national monuments. Then ask students questions 1c and 1d.
   a. Were there any milestones that addressed the protection of organisms?
   b. What were they? (Students may mention the two presidential proclamations.)
   c. Why is creating protection for certain species important?
   d. Do some species need more protection than others? Why or why not?
2. Remind students that the PRIMNM is one of the largest conservation areas in the world and helps to protect many threatened and endangered species.
3. Explain the term "marine national monument" and describe how it can contribute to conservation.
4. Ask students to help you list the four marine national monuments in the Pacific.
   a. Pacific Remote Islands Marine National Monument
   b. Papahānaumokuākea Marine National Monument
   c. Mariana Trench Marine National Monument
   d. Rose Atoll Marine National Monument
   e. Each MNM provides protection for a collection of species within its boundaries.
5. Tell students that they will do some additional research to learn more about each marine national monument and create posters that highlight the conservation issues being addressed within each one.
6. Place students into four groups, and assign each group one of the marine national monuments.
7. Give each student a marine national monument organizer worksheet and review the questions. Let students know that the information they gather for this worksheet can help to inform what they include on their final poster.

8. Also remind students that they can refer back to the resource worksheet they received in the first activity as a starting point for their research.

9. Once students have completed their research and filled in their organizer, they should discuss with their team how to create their group poster. Give each group one poster board and art materials to begin designing.

10. Display each poster and have all groups present their findings in a five-minute presentation.

11. After each group has presented, lead a discussion using the following guiding questions:
    a. What are some similarities and differences among the four MNMs?
    b. What are some of the major problems faced by each MNM?
    c. Are there any organisms that are found in all four?
    d. How would you describe the goal of the MNMs in your own words?

12. Possible extension for older students: For an additional challenge, students in 4th–5th grades can write an essay that describes the impact of the creation of the marine national monuments on the environment.

Marine National Monument Poster Organizer

Student Name:

Your group will create a poster for one of the four marine national monuments (MNMs). Research your assigned area to learn more information. Your poster should address all of the questions in the chart below.

Circle the MNM your group is focusing on: Papahānaumokuākea MNM   Mariana Trench MNM Rose Atoll MNM   Pacific Remote Islands MNM
Are there any unique features of this monument?
What kinds of habitats are found there?
What are the key species or organisms found there? Are they threatened or endangered?
How do these organisms interact with each other?
What kind of research is being conducted in this monument?
What do you think might happen to this area or the organisms that live here if it wasn't designated as a marine national monument?
What one conservation message would you like to get across with your poster?

ATOLL REEF FORMATIONS

Coral reef within the Palmyra Atoll National Wildlife Refuge, part of the Pacific Remote Islands Marine National Monument. This area has some of the most pristine coral reef habitat in the world.

Image courtesy of *Hidden Pacific*

ATOLL REEF FORMATIONS

Overview: Students observe a demonstration that helps to model the steps of atoll formation.

Grade Level: K–4th grade

Next Generation Science Standards:

- **K-LS1-1:** Use observations to describe patterns of what plants and animals (including humans) need to survive.
- **K-ESS2-2:** Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
- **2-ESS1-1:** Use information from several sources to provide evidence that Earth events can occur quickly or slowly.
- **2-ESS2-2:** Develop a model to represent the shapes and kinds of land and bodies of water in an area.
- **4-ESS2-1:** Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
- **4-ESS2-2:** Analyze and interpret data from maps to describe patterns of Earth's features.

Objectives:

Students will be able to:

- Describe the steps in the process of atoll formation.
- Model the formation of an atoll.
- Explain the role that corals play in creating an atoll.

Time: 30 minutes

Background Information:

An atoll is a ring-shaped coral reef, island, or series of islets. Atolls surround a body of water called a lagoon, sometimes also protecting an island at the center of the ring. Atolls develop with seamounts (underwater volcanoes). When the volcano erupts, the lava builds up on the seafloor continuously, until the elevation is so high, the seamount breaks the surface of the water and the top of the volcano becomes an island.

Hermatypic, or hard, corals begin to colonize around the island and build a reef. This fringing reef surrounds the island just below the ocean surface. Over time, the volcanic island begins to erode and sink to the seafloor. As it erodes into the sea, the top is made flat by constant pounding of ocean waves, becoming a guyot. As this subsistence continues, corals grow upward to stay within the shallow water zone where they can still receive enough sunlight. Through this process, the fringing reef becomes a barrier reef, which is now further from shore and also results in a deeper, protected lagoon. The ocean waves also break apart pieces of the reef, grinding the limestone skeleton on grains of sand. This sand and other material are deposited by the waves or piled up on the reef, creating ring-shaped islands and islets. This process can take tens of thousands to millions of years.

The Pacific Remote Islands Marine National Monument includes several atolls: Palmyra, Johnston, and Wake Atolls. Johnston Atoll is considered to be one of the oldest atolls in the Pacific Ocean and is comprised of four islands. It supports at least 45 coral species, including over a dozen species that are found there and in Hawaii. Large populations of sea turtles, whales, seabirds, and reef sharks can also be found at Johnston Atoll as well.

Palmyra Atoll is the remnant of a volcano from 65–120 million years ago! It is comprised of about 50 islets and a few lagoons. Palmyra Atoll has a high level of coral diversity, with other 180–190 species present. There are also many nationally and internationally threatened, endangered, and depleted species, such as sea turtles, pearl oysters, giant clams, reef sharks, fish, and dolphins, that thrive there. The area supports the breeding populations of 11 species of seabirds, including one of the largest red-footed booby and black noddy colonies in the Central Pacific.

Wake Atoll is the northernmost atoll in the Marshall Islands geological ridge and perhaps the oldest living atoll in the world. The atoll provides important seabird and migratory shorebird habitat, as well as vibrant coral reefs that support large populations of fish in the monument waters. More than 300 fish species and 100 coral species thrive on the shallow coral reefs, along with giant clams, marine turtles, and spinner dolphins.

Below are links to a video and animation that show this formation process very clearly.

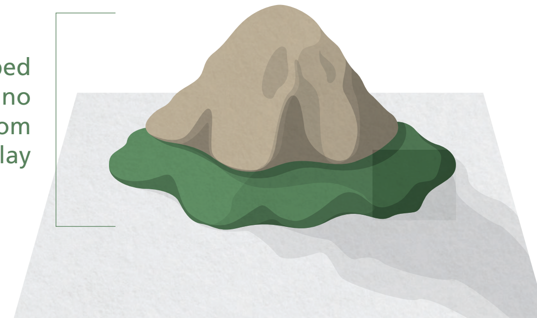
Video: https://www.livingoceansfoundation.org/video/birth-of-an-atoll/

Animation: https://oceanservice.noaa.gov/education/kits/corals/media/supp_coral04a.html

Activity 1: Atoll Reef Demo

(Adapted from Earth Learning Idea's "Darwin's 'Big Coral Atoll Idea'")

Time: 30 minutes

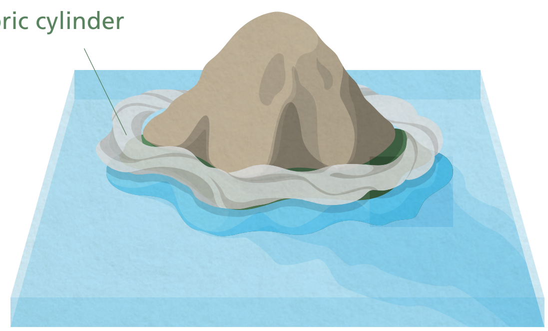


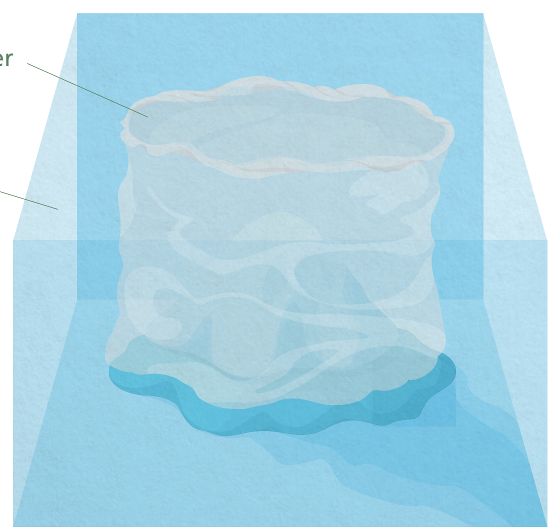
Materials:

- ☐ Pictures of different atolls
- ☐ Tape
- ☐ Modeling clay or cardboard
- ☐ Wire
- ☐ Fabric or a stocking
- ☐ Five-gallon aquarium
- ☐ Water
- ☐ Bucket
- ☐ Construction paper
- ☐ Markers, crayons, or colored pencils

Setup:

1. Create the atoll model.
   a. Create a fabric cylinder. If using a stocking, cut the foot off.
   b. Create a cone-shaped volcano from the modeling clay or cardboard. The cylinder from step 1 should be able to fit over the volcano.
   c. Attach the wire in a circle at one end of the cylinder from step 1. Secure with tape.
   d. Place and secure the volcano in the center of the aquarium. Secure the cylinder around it. (See picture.)
2. Fill bucket with water and set aside.





Procedure:

1. Show students pictures of different atolls and ask them to make some observations. What do they notice?
2. Explain that atolls are ring-shaped coral reefs, islands, or a series of islets, and at one point in history, the ring at the center was occupied by a large volcano!

3. Let students know that they will watch a demonstration that showcases how an atoll forms.

4. Show students the aquarium model. Point out the shape in the center and ring of fabric around it. Ask students to discuss what these materials represent.
   a. The cone represents the volcano.
   b. The ring of fabric represents the reef. Currently, it is a fringing reef.

5. Explain to the students that in order for the atoll to form, the volcano must sink. We will represent this by adding water to the tank.
   a. Ask for a volunteer to assist you in pouring water from the bucket slowly. Have them stop when the very tip of volcano model is still above the water.
   b. What do the students observe as the water fills the tank and the volcano "sinks"?
      i. Students should see the fabric cylinder rise as the volcano is submerged.
      ii. The ring of fabric should be floating at the surface around the top of the volcano.

6. Explain to the students that as the volcano sinks, or subsides, the corals grow upwards to stay close to the surface.
   a. Ask students: Why might the coral need to remain close to the surface as the volcano sinks?
   b. Take a few responses and share that corals need sunlight to support the zooxanthellae (algae) living within their polyps. The zooxanthellae helps to provide them with food and the energy needed to grow.
   c. Continue explaining that as the volcano sinks slowly, the fringing reef becomes a barrier reef because it is now separated from the land and helps to protect the lagoon that it encircles.

7. Ask for another volunteer to help pour the rest of the water. This time the volunteer should pour what is remaining until the ring is floating high above the volcano. Again, ask students for their observations. Explain:
   a. Eventually, the volcano sinks completely, leaving the ring of the coral reef near the surface.
   b. This is the atoll.

8. Ask the students how long they think it takes for this process to occur. Let them know that this process can sometimes take as much as a million years!

9. Show students the following video to give them another visual representation of atoll formation: https://www.livingoceansfoundation.org/video/birth-of-an-atoll/

10. Tell students to use what they have learned to draw the steps of atoll formation.
    a. Give each student a sheet of construction paper.
    b. Have them fold the paper twice, to create four boxes. They should label each box 1–4.
    c. In each box, students should draw their depiction of atoll formation.

11. Display student drawings throughout the classroom.

CORAL REEF COMMUNITIES AND THE IMPORTANCE OF BIODIVERSITY

A school of fish swims through a coral reef within the Palmyra Atoll National Wildlife Refuge. A healthy coral reef supports a diverse community of organisms.

Image courtesy of *Hidden Pacific*

CORAL REEF COMMUNITIES
AND THE IMPORTANCE OF BIODIVERSITY

Overview: Students will learn how coral reefs are created, the importance of a healthy biodiverse reef ecosystem, and explore the diverse number of organisms that live on a coral reef through role playing and creating a coral reef ecosystem mural.

Grade Level: 2nd–5th grade

Next Generation Science Standards:

› **2-LS4-1:** Make observations of plants and animals to compare the diversity of life in different habitats.

› **3-LS1-1:** Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

› **3-LS4-3:** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

› **4-LS1-1:** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

› **5-LS2-1:** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Objectives:

Students will be able to:

› Identify that a coral polyp is an animal and explain its symbiotic relationship with algae.

› Develop a coral reef atoll and describe the life cycle of coral reefs.

› Model how animals in the coral reef ecosystem are interconnected and all life in the coral reef is interrelated.

› Name five species that live in the Palmyra Atoll reef.

› Identify at least one benefit of having a diverse coral reef ecosystem and one factor that can harm the ecosystem.

Time: 2 hours 15 minutes

Background Information:

Coral reef ecosystems are like bustling cities of the sea, containing thousands of inhabitants that come and go, interacting with each other and making the corals their homes. Coral reefs support an estimated 25% of marine life and have evolved into one of the largest and most complex ecosystems on the planet.

Corals are animals that belong to the group phylum Cnidaria, marine invertebrates that are closely related to anemones, sea jellies, and hydra. “Cnidaria” comes from the Greek word “cnidos” which translates to stinging nettle. The basic construction of a coral is its polyp—a bag-like structure that has a trunk, mouth, and tentacles.

There are two main types of corals: soft and hard corals. Soft corals are flexible organisms (resembling plants and trees) that do not have stony skeletons and cannot produce reefs. The corals that build reefs are known as hard corals. Corals begin as free swimming larvae and attach themselves to a solid substrate. The larvae develops into a polyp and the individual coral polyps connect to each other via a thin layer of tissue. To build the reef, each hard coral polyp extracts calcium carbonate ions from the seawater to deposit limestone outside of its tissue, creating a hard skeleton around the polyp in unique and complex shapes that are specific to each species. Through an endless cycle of growing and dying, over time the coral creates a limestone foundation on which coral reefs are built. As the coral polyps fuse their skeletons together to form large coral colonies, the limestone skeleton elevates the polyp communities off the seafloor.

Many corals live in a symbiotic relationship with single celled algae called zooxanthellae. This algae lives within the cells of the animal and carries out photosynthesis. The coral and zooxanthellae have a mutualistic relationship, meaning both species benefit from living together. The zooxanthellae creates and provides food, in the form of sugar, to the coral. The coral excretes ammonium that the algae are able to take up and use. The algae help increase the growth of the limestone skeleton, which is essential for the construction of large reefs. The algae also contribute to the coral’s bright color. In addition to corals obtaining their food and nutrients from zooxanthellae, corals are also predators. Coral polyps can extend their tentacles outside of their skeleton to capture zooplankton, bacteria, and other dissolved material floating by. The corals sting their prey with harpoon looking cells called nematocysts that temporarily subdue their prey. Then they use their tentacles to push the prey into their mouths and digest in their stomachs.

Different species of coral grow at different rates depending on their environment. Water temperature, salinity, turbulence, pH, light, and the availability of food are all factors that can affect the growth of corals. Massive corals are the slowest growing of the species, growing about 5–25 millimeters (0.20–1 inch) per year. Other corals, such as branching and staghorn corals, can grow as much as 20 centimeters (8 inches) per year. It is possible to find corals living at depths up to 300 feet, but reef-building corals typically grow poorly at depths beyond 60–90 feet.

When the environment changes, this can affect the growth rate and possibly cause coral bleaching. For example, sediment, pollution, and plankton can cloud the water, blocking out the sun and harming the polyps. Wastewater discharged near a coral reef can contain nutrients that allow for seaweed to rapidly grow and over take the reef. When corals get stressed from any of these changes, the algae leaves the polyp, which turns the coral white in a process called coral bleaching. When a coral bleaches it is not dead. Corals can survive bleaching but the stress can also lead to mortality. Having clean, clear, salty, and warm water are very important factors in the success of a healthy coral reef.

Coral reefs create homes necessary for hundreds of organisms to live. While the structure of coral reefs is mainly made from hard corals, other types of animals and plants, such as algae, seaweed, sponges, mollusks, and giant clams and oysters, contribute to the unique architecture of coral reefs. When these organisms die, they create a foundation for new coral to grow.

At the Palmyra Atoll National Wildlife Refuge, there are 176 species of corals, 147 species of algae, and approximately 418 species of reef fish. Each one of these organisms plays an important role in the reef community. For example, parrotfish scrape at the coral to get to the small algae that live inside the coral polyp, and then they grind up the coral skeleton as they eat it and excrete it as sand. The white sand builds up over time and creates beaches, which serve as a perfect spot for threatened green turtles and endangered hawksbill sea turtles to lay their eggs.

A healthy coral reef ecosystem has a predator dominated marine ecosystem, and Palmyra Atoll has an abundance of sharks, groupers, jacks, snappers, and other predatory fish that keep populations of smaller fish in balance. Some predators of corals include the crown of thorns starfish, parrotfish, and butterfly fish.

Biodiverse coral reefs are important for many reasons. A highly diverse coral reef ecosystem is more resilient to changing conditions and can withstand significant disturbances better. Having a diverse range of species provides a larger gene pool that give communities more survival options when the environmental conditions change due, for example, to climate change, overfishing, and pollution. The extinction of one species can have a significant impact on many other organisms.

Reducing biodiversity leads to the breakdown in ecosystem health and functionality. Some species that are threatened, endangered, or depleted at other coral reefs thrive at Palmyra. Resilient reefs can help repopulate reefs all around the world. By protecting Palmyra, scientists can take the information learned by studying the healthy species and ecosystems in this reef and apply it to ecosystems in other parts of the world that are in need of restoration.

Activity 1: Construction of a Coral Reef Mural

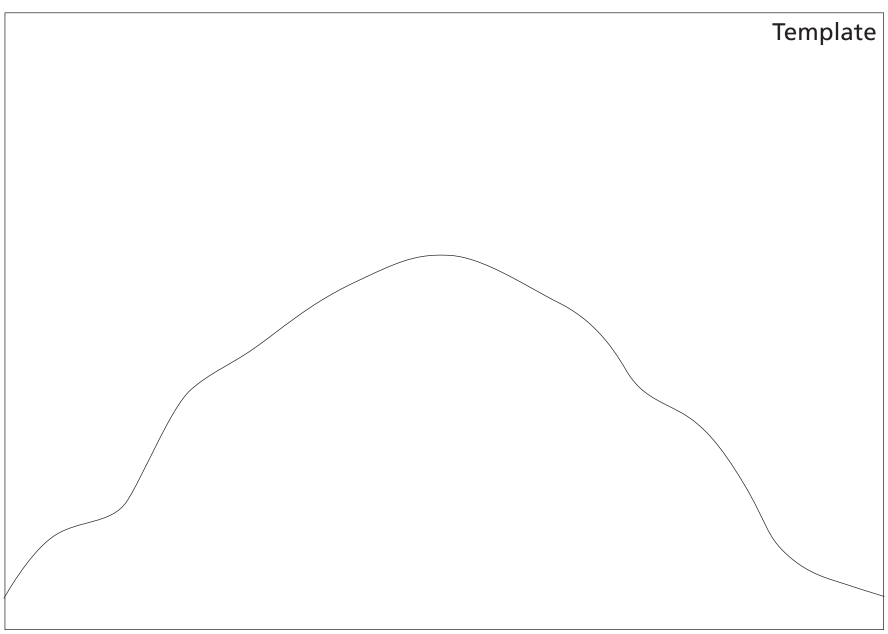
Time: 30 minutes

Materials:

- ☐ Coral cards (40)
- ☐ 20 hard coral cards
- ☐ 20 soft coral cards
- ☐ Atoll formation template
- ☐ Colored pencils
- ☐ Image of corals from movie for display (either on computer or poster)
- ☐ Blue butcher paper
- ☐ Glue or tape
- ☐ Pencils

Setup:

1. Create coral cards.
   a. Find pictures of 20 hard corals found in the Pacific. Species can be duplicated.
   b. Find pictures of 20 soft corals found in the Pacific. Species can be duplicated.
   c. Cards should be no larger than 2 inch x 2 inch.
2. Cut butcher paper. Suggested size is about 3 yards wide and 2 yards tall.
3. Transfer or copy the atoll formation template (below) onto the blue butcher paper.



Procedure:

1. Begin by asking the students: What is one thing you remember or one thing you learned from the movie about coral reefs? Take a few responses.

2. Ask the following questions: What is a coral reef? How do coral reefs form? Do you think a coral is a plant or an animal?
   a. Accept all ideas and answers. Elaborate on students' answers and review the following information:
      i. Anatomy and functions of a coral polyp and the internal and external structures that function to support survival and growth
      ii. Symbiotic relationship with zooxanthellae and what happens when corals bleach
      iii. The environment corals need to survive and grow: warm water, clear water, salt water, clean water

3. Show students the images of Palmyra Atoll coral reef and ask for observations about the coral reef.
   a. Guide the students to notice the diversity of coral species in the reef and where types/shapes of coral are located within the atoll.
   b. Have students share their observations.

4. Tell the students that today they will build their own coral reef ecosystem.

5. Pass out the coral cards so every student gets one hard coral card and one soft coral card.

6. Give students about 1–2 minutes to look at the cards and compare them to those of their classmates next to them. Ask them to think about how the corals on their cards are similar to or different from their classmates.

7. Have the students match their hard and soft coral cards with similar coral species in the picture of the Palmyra Atoll coral reef.

8. If cards are in black-and-white, once they have found their coral in the picture, they should color it to match.

9. Show students the drawing of the atoll on the butcher paper. Ask students: Where on the atoll would the coral reef begin? Would that coral be alive or dead? What will happen over time?

10. Have students identify the different parts of the atoll formation: volcano, seafloor, coral rubble base, and living coral.

11. Now, have the students work together to glue/tape the coral cards on the butcher paper template to create the coral reef.

12. Possible extension activity:
    a. For homework, have students research additional organisms (invertebrates, fish, turtles, plankton, algae, etc.) that could be part of their Palmyra Atoll coral reef ecosystem.

b. Each student should identify two organisms; create a short biography for the organism describing its habitat, predators/prey, special adaptations, and behavior; and draw them.

c. Each student should present their organisms to the class, and then add them to an appropriate location on the mural.

Activity 2: Testing the Importance of Biodiversity

Time: 45 minutes

Materials:

- ☐ Coral cards (2 sets)—see instructions in Setup below
- ☐ Pencils

Setup:

1. Create coral cards.
   a. Set 1:
      i. Select one coral species from the Palmyra Atoll.
      ii. Find a picture of the species and print out 20 copies.
   b. Set 2:
      i. Select 4–5 additional coral species and find pictures of each.
      ii. Print 4–5 copies of each species.
      iii. Print five more copies of the species selected for Set 1.
      iv. You should have a total of 20 cards.

Procedure:

1. Hand out the coral cards in Set 1. Tell the students that we are one large community of the same type of coral.
   a. Ask students: Is it good, bad, or will it have no effect on our ecosystem if we are all the same type of coral? Why?
   b. Have the students turn and talk to a partner about their hypothesis and evidence for their reasoning. They can write these ideas down in their science journal.
2. Have all the students stand up with their coral card in one hand and a pencil in the other.
3. Instruct students to walk around the room and shake hands with four other students, writing the names of the students they shook hands with on the coral card.
4. When each student is done, have them go back to their seats but remain standing.
5. Let them know that you will be representing a coral killing disease, or environment stressor (like rising water temperature, increased salinity, or pollution) and will shake hands with one student.
   a. Select one student at random and shake their hand.
   b. Tell that student that they must take a seat as they have been impacted by the disease or stressor and are now dying.

c. Ask the student to read off the names on their card.

d. Any student whose name is called should also sit down.

e. Have each of those students read the names off of their cards and instruct the new names called to sit as well.

f. This should continue until almost everyone is sitting or until there are no more names to call.

6. Ask the students to explain why the disease spread so fast. What was their hypothesis before the activity and how did their ideas change now that they've observed what happened? Take some responses.

7. Explain to the students that they will do the activity again, but this time with a new set of coral cards.

8. Hand out Set 2 and repeat the handshaking activity. Students will once again shake hands and write down the names of classmates they shook hands with.

9. You will again represent the disease/stressor.

   a. Choose another student at random and shake their hand.

   b. The students sit and read the names on their card. But this time, before sitting, have the students who were called compare their card to the first student.

   c. Only students who have the same coral will die and need to sit. Students with other species on their cards don't die, even if they shook hands with the diseased coral. They can remain standing.

   d. Any students who sit should read the names on their cards, repeating the above steps until no one else is affected.

10. Lead a discussion with the students using the following guiding questions:

   a. How was this round different from the first one?

   b. Why did the disease not spread as much as the first time?

   c. Why do you think that is?

   d. What are some other circumstances that might lead to the die-off of certain species? Responses might include if the water gets too warm, the coral gets too deep, increase in salinity, increase in pollution, a change in pH, decline in certain food, turbidity, etc.

   e. What might happen on in a real reef community with each scenario?

   f. Might there be any ways to ensure that scenario doesn't occur?

11. Introduce the term biodiversity to the students and ask them to identify which round had a biodiverse community. Discuss its importance.

   a. How would a biodiverse coral community benefit humans?

   b. How could humans be harming a biodiverse coral community?

   c. If you have time, share stories of real situations where this has happened in coral reefs; for example, black band disease that affects brain coral.

Activity 3: A Day in the Life of a Coral Reef Community

Time: 60 minutes

Materials:

- ☐ Paper or index cards to create animal cards (28)
- ☐ Colored pencils
- ☐ Glue/tape
- ☐ Construction paper

Setup:

1. Create animal cards.
   a. Find pictures of the following organisms:
      i. Green Turtle
      ii. Manta Ray
      iii. Plankton
      iv. Blacktip Reef Shark
      v. Parrotfish
      vi. Crown-of-Thorns Starfish
      vii. Trapezia Crab
   b. Print four pictures of each organism, with the image on one side and its description on the other. See descriptions below:
      i. Green Turtle—These turtles come back to an island every two years to lay their eggs on the white sand beaches. Some of the white sand is made up of parts of coral that parrotfish have ground, eaten and excreted through their digestion process.
      ii. Manta Ray—At night the manta rays feed on plankton in the lagoon.
      iii. Plankton—Plankton serve as food for a lot of animals in the coral reef, including corals and manta rays. Too many plankton, however, can cloud the water and make it difficult for sunlight to reach the zooxanthellae, slowing or stopping the process of photosynthesis. Eventually this can cause coral bleaching.
      iv. Blacktip Reef Shark—One of the main predators in the reef. The sharks help regulate the fish population size by eating fish.
      v. Parrotfish—Feed on the algae inside the coral polyp. They grind up the hard coral skeleton and, as they excrete it, it falls to the ocean and eventually builds up to help create beaches.
      vi. Crown-of-Thorns Starfish—Covered in long poisonous spines, they eat nearly all types of corals. The overfishing of predators of this sea star can create a high population of this sea star in one area that can overtake coral communities and kill them.

vii. Trapezia Crab: These crabs nestle and live inside stony corals. They have a mutualistic symbiotic relationship with the coral. They feed on the fats that they harvest from the tips of the tentacles on the polyps. In return for the food, the crabs remove sediment from the coral and "clean" them. Trapezia crabs also help save coral from the crown-of-thorns starfish. They pinch off the sea star's tube feet, spines, and other soft parts to save their coral home from being under attack.

c. Create two sets of cards. Each set should have two of each animal.

2. Pre-cut strips of construction paper for headbands.

Procedure:

1. Begin by asking the students to think back to the movie and ask: What kinds of animals live in or around coral reefs?
    a. Write some of the animals they suggest up on the board.
    b. Ask students: How do you think these different animals interact with each other?
2. Group students into approximately two groups of 10–14 students each and pass out an animal card set to each group. (This can also be done in smaller groups of 5–7 students. For smaller groups, each card set should have only one of each animal.)
3. Have students read their cards out loud to their group so everyone has an idea of what each animal does and who they might interact with in the community.
4. Students will work together to create a 3–5 minute skit about a day in the life of their coral community.
    a. The skit should show and explain how each animal interacts with each other and the environment.
    b. Allow students to do more research to learn about their animals.
        i. Students should research a new connection or relationship that an animal has in the coral reef ecosystem. They should also include more relationships about interactions with plants and other animals, and how these interactions allow for multiple species to meet their needs.
        ii. Students can then incorporate that new information into the skit.
    c. Encourage students to use the information they learned and to make the skit creative, funny, and entertaining, bringing in popular references.
    d. Also, give each student a strip of construction paper to create a headband by taping their animal card to the construction paper. They will wear the headband when performing their skit.
5. Each group will perform their skit in front of the class and in front of the coral atoll mural made during Activity 1.
6. After each performance, that group will tape or glue their animal cards to the coral reef mural to create a flourishing and biodiverse ecosystem.

7. Lead a discussion and review with the students, using the following as guiding questions:
   a. How do coral reefs form?
   b. What does biodiversity mean?
      i. Why is it important?
      ii. Are the ecosystems featured in the *Hidden Pacific* film biodiverse? Why or why not?
      iii. Where else can you find biodiverse ecosystems?
   c. What is one thing you could tell someone about coral reefs?

GREEN SEA TURTLES

Green sea turtle resting on a beach within the Papahānaumokuākea Marine National Monument. Sea turtles often return to the beaches where they hatched to lay their own eggs.

Image courtesy of *Hidden Pacific*

GREEN SEA TURTLES

Overview: Students will play a game of tag to illustrate the ways in which bright lights interfere with the navigation abilities of sea turtle hatchlings. They will then return to the classroom, discuss conservation threats they identified from the game and the reading, and make a poster communicating a solution to one of these issues.

Grade Level: 2nd–3rd grade

Next Generation Science Standards:

› **3-LS1-1:** Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

› **3-LS4-3:** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

› **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.

Objectives:

Students will be able to:

› Discuss the role that female sea turtles play in the hatching of their eggs.

› Brainstorm and identify threats to green sea turtle populations, both natural and human-made.

› Compare green sea turtle nesting habitats in the Pacific Remote Islands Marine National Monument to nesting habitats near other coastal cities.

› Model the journey of baby green sea turtles from the nest to the ocean.

› Describe potential actions that could aid green sea turtles.

Time: 1 hour 30 minutes

Background information:

Green sea turtles are the largest species of hard-shelled sea turtles and can weigh up to 700 pounds, with many individuals weighing 300–400 pounds on average. Green sea turtles get their name from the green color of their fat. It is believed that this color is due to the plant-based diet of the turtle, as it primarily eats a variety of algae and seagrass. Green sea turtles can spend up to five hours underwater before coming up for air. However, when they are active, they will alternate between being underwater for a few minutes and coming to the surface to breathe for a couple seconds. While most sea turtles warm themselves by swimming close to the surface, green sea turtles in the Pacific Remote Islands Marine National Monument (PRIMNM) will often take to land to bask in the sun. They can usually be seen basking on the two small coral rubble ridges that emerge at Kingman Reef.

Green sea turtles can migrate long distances between their feeding grounds and their nesting sites. PRIMNM hosts nesting sites for over 200 green sea turtles. Female turtles leave the water in order to lay eggs on the beach, digging a nest with her flippers to deposit over 100 eggs. The eggs are covered with sand before the female returns to the water. After about two months, the eggs hatch and the baby turtles make their way to the water.

Newly hatched sea turtles are at risk of being hunted by animals such as birds, crabs, and raccoons as they move from their nests out to the sea. Once at sea, they spend the first few years of their lives floating in the open ocean, where they feed on plankton and attempt to avoid additional predators. As they grow older, green sea turtles move to shallow waters along the coast, where they can find seagrass to eat.

All green sea turtle populations are listed as either threatened or endangered under the Endangered Species Act. The Endangered Species Act is an act of government legislation that serves to protect endangered and threatened species and their habitats. Adult green sea turtles in other parts of the world face many threats, primarily from humans, including harvesting, injuries from boat propellers, being caught as bycatch, pollution, loss of nesting habitat, degradation of foraging habitat, and poaching (for their shells). PRIMNM serves as a critical refuge for these animals, free from human threats.

Activity 1: Sea Turtle Beach Tag

Time: 45 minutes

Materials:

- ☐ Identical traffic cones or Frisbees (4)
- ☐ Printed illustrations (4)
    - ☐ Ocean with moonlight
    - ☐ Hotel with light coming from the windows
    - ☐ Street lamp
    - ☐ Flashlight
- ☐ Access to large field, gymnasium, or other space to run around

Setup:

1. Tape photos to the underside of traffic cones or Frisbees so they can be seen easily when cone is lifted up.
2. Identify boundaries for the playing area.

Procedure:

1. Bring students to the center of the playing area and have them sit.
2. Ask students to recall the scenes from the *Hidden Pacific* movie that featured the baby green sea turtles. What do they remember? Discuss the following:
    a. Female green sea turtles come onto shore to dig nests and lay eggs.
    b. After laying eggs, the female turtle returns to the water.
    c. Once the eggs hatch, the new baby turtles are on their own and must find their way to the ocean.
3. Ask students whether they think the young turtles have any predators and have them brainstorm ideas on what kinds of organisms might pose a threat to young sea turtles. Remind them to think of organisms they may have seen in the film that reside in the Pacific Remote Islands Marine National Monument (PRIMNM).
4. Explain to the students that they will play a game where they will model newly hatched sea turtles trying to get to the ocean.
    a. Ask for 2–3 volunteers to play predators identified earlier (a crab and a seagull are two options).
    b. Sea turtles will need to make it from the center of the playing field to the finish line (the play area boundary) without being caught by the predators. They'll know which boundary to go to by finding the cone and heading towards it.

c. If any baby sea turtles get caught, they become a predator too and can hunt other baby sea turtles.

5. Discuss safety-related ground rules (boundaries of game field, no shoving, no guarding the cone, etc.).

6. Place the traffic cone with the picture of the moon near one of the boundaries and ask the "predators" to stand between the cone and where the "sea turtles" are sitting.

7. Begin the game. Play for three minutes. At the end of the round, count the number of sea turtles that were successful.

8. Call all students back to the center of the play area. Lead a discussion using the following questions:
   a. Was it easy or hard to find the ocean (finish line)? Why or why not? (Students may mention that they looked for the cone.)
   b. Do you think it would be easy or hard for a baby sea turtle to make it to the ocean? Why or why not? Do they have any help?
   c. Explain that baby sea turtles have to find their way to the ocean on their own, especially as they often hatch at night. What can they use in the dark to help them find their way?
      i. If a student mentions the moon, show them the picture of the moon over the ocean on the underside of the cone.
      ii. Point out that the bright light from the moon reflects on the water and makes the ocean brighter than the sand.
      iii. So the traffic cone/marker they were running towards was similar to the moonlight reflecting on the water.
   d. Are there any other sources of light at night other than the moon?
      i. If students struggle to come up with some, ask them how they find their way around at night.
      ii. When someone mentions artificial light sources, ask for ideas of types of light sources that might be on or near a beach (possible ideas include houses, hotels, street lights, cars, bonfires, and flashlights).
   e. Would these additional sources of light make it easier or harder for the turtles to get to the ocean?

9. Tell students that they will be playing another round, but this time there are multiple cones to represent the extra light sources that were just discussed.
   a. Show them the bottoms of the cones with the light source images.
   b. Tell them the cones will be placed at random around the play area and they will try to find the one that leads them to the ocean.
   c. When students get to a cone, they should flip it over to see if they are at the ocean or not.
      i. If they are at the ocean, they can continue on to the finish line and exit the game.

ii. If they are not at the ocean, they have one more try to find the right cone. If they don't locate the ocean, they will move back to the center of the play area and take a seat.

d. Like in the first round, if a turtle is tagged by a predator, they become predators and hunt other turtles.

10. Place all the cones on the field and start the round. At the end of the round, count the number of sea turtles that made it to the ocean.

11. Play a few more rounds, shuffling the cones each time and counting the number of survivors at the end of each round.

12. Gather back up the group and lead another discuss using the following as guiding questions:

    a. Which way of playing was easier?

    b. If you were actually a turtle, which version of the game would you prefer?

    c. Ask if any students shouted to each other which cone was the real ocean. Would sea turtles have the same option?

    d. Which version of the game do they think is most like what happens in the PRIMNM? Why?

    e. Since multiple light sources in major cities can make it difficult for baby sea turtles, what are some things humans living or working near the beach could do to help make the turtle's journey easier during hatching season?

        i. Show students images of typical beachfront lighting versus sea-turtle-friendly lighting, and discuss how this is just one example of how people can change their behavior to help lessen human impact on wildlife.

        ii. Another example may be to designate protected wildlife areas like the PRIMNM featured in the documentary.

13. As an extension activity, students can do additional research on ways to assist baby sea turtles in populated coastal cities and present the various options.

Activity 2: Green Sea Turtle Conservation Poster

Time: 45 minutes

Materials:

- ☐ Markers, crayons, or other art supplies
- ☐ Poster board (10)
- ☐ Books and magazines on green sea turtles and sea turtle conservation or access to computers with internet access

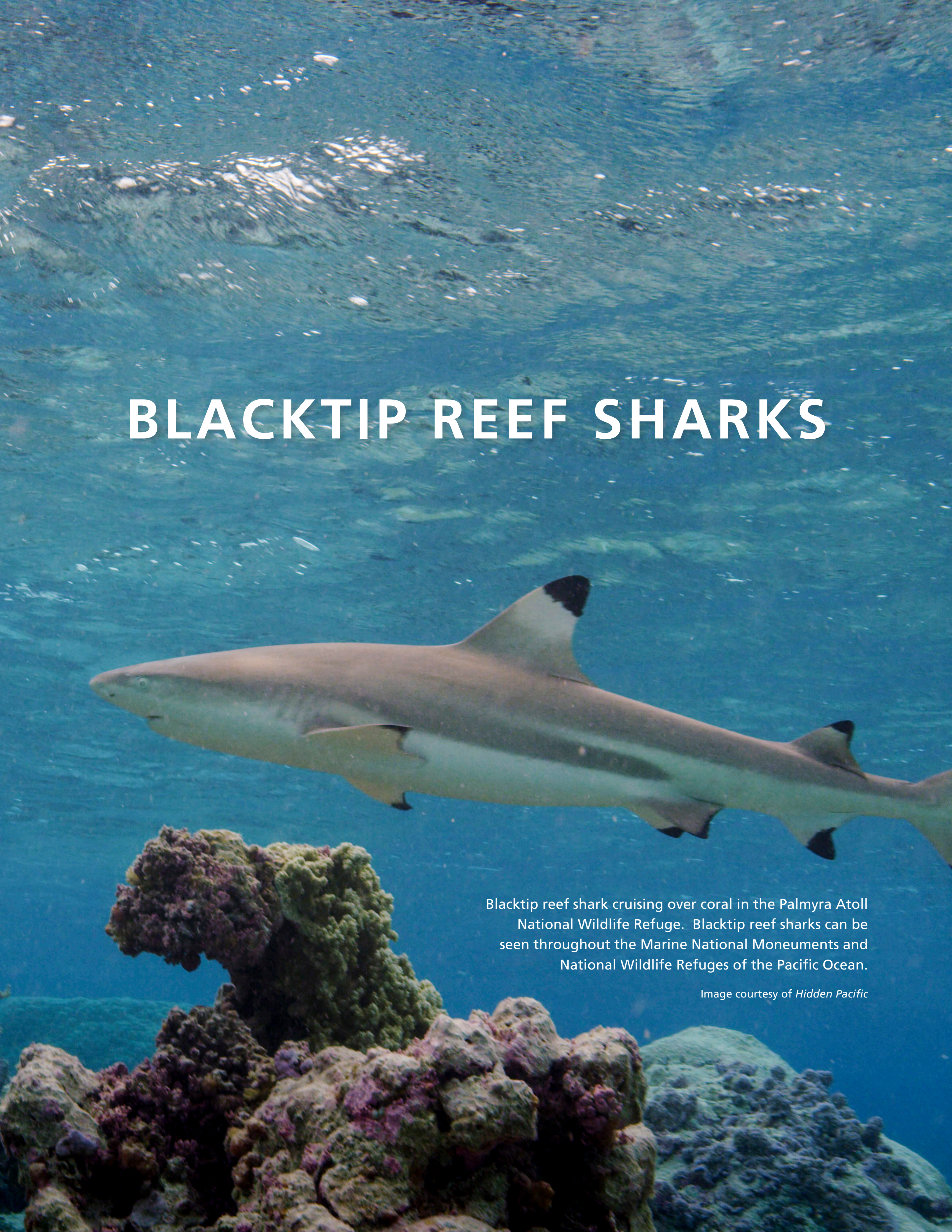
Setup:

1. Optional: Create a list of potential websites students can use to do research.

Procedure:

1. Discuss as a class some potential dangers to green sea turtle populations.
    a. This includes pollution, fishing, boats, loss of habitat, predators, etc.
    b. Discuss specifics of how those challenges may make life harder for sea turtles (examples: pollution can make animals sick, habitat loss means they may not be able to find places to make nests, etc).
2. Place students into pairs and lead them through a think—pair—share structure to brainstorm potential ways people could help with these problems turtles face.
3. Have each pair share at least one idea they'd like to research further. Give them time to research in class or assign as a homework assignment. If you created a list of websites, share the list with the students.
4. Tell students they are now going to make a poster telling people about one way they could help green sea turtles. Their posters should include:
    a. General information on green sea turtles
    b. How this conservation strategy helps with one of the problems green sea turtles face
    c. Other resources (books, websites, organizations) people can reach out to for more information or volunteer opportunities
5. Have each pair present their poster to the class, then display the posters throughout the classroom.

BLACKTIP REEF SHARKS



Blacktip reef shark cruising over coral in the Palmyra Atoll National Wildlife Refuge. Blacktip reef sharks can be seen throughout the Marine National Moneuments and National Wildlife Refuges of the Pacific Ocean.

Image courtesy of *Hidden Pacific*

BLACKTIP REEF SHARKS

Overview: Students review the importance of shark skin, review the purpose of shark fins, and explore the dangers of fishing on shark species like blacktip reef sharks.

Grade Level: K–5th grade

Next Generation Science Standards:

- **K-ESS3-3:** Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
- **3-LS4-3:** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
- **4-LS1-1:** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- **5-ESS3-1:** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Objectives:

Students will be able to:

- Describe and define the texture of shark skin.
- Identify and describe the functions of the fins of a blacktip shark.
- Model several different fishing techniques.
- Discuss the impacts of different fishing techniques on blacktip reef sharks.
- Brainstorm conservation strategies to help protect blacktip reef sharks.

Time: 2 hours

Background Information:

Blacktip reef sharks are fast-swimming, active sharks that live in coral reef communities. They can be found in many tropical Pacific reefs, including the reefs found within the Pacific Remote Islands Marine National Monument (PRIMNM). In addition to coral reefs, blacktips can also be found in estuaries, bays, and the shallow waters near beaches.

Blacktip reef sharks are sometimes seen above the water, as they tend to leap above the surface, rotate, and splash down on their backs. This display is sometimes part of a feeding method used to strike schools of fish near the surface. Blacktip sharks also feed on skates, stingrays, squid, and crustaceans. They have also been seen following fishing boats to feed on discarded bycatch.

Because blacktip reef sharks like shallow, inshore waters, they are extremely vulnerable to coastal development, which can eliminate critical habitat such as nursery sites. They are also vulnerable to commercial fishing, where they can be caught as bycatch or are targeted specifically for their tasty meat and fins.

Palmyra Atoll, located within the PRIMNM, is one of the few places remaining where sharks, like blacktip reef sharks, and other large apex predators, still dominate the marine ecosystem. Because the area is protected, it is completely off limits to commercial fishing.

Between 2006 and 2014, researchers tagged 1,300 blacktip reef sharks at Palmyra. Large-scale tagging projects like this help us to understand potential threats to shark populations. Though blacktip reef sharks are not a threatened species, many shark species have seen steep declines from habitat loss and overfishing. By knowing how blacktips behave and where they go, researchers can help to protect these and other shark species in the long run.

Activity 1: Rough Sharks

Time: 20–30 minutes

Materials:

- ☐ Sandpaper (10 full size sheets)
- ☐ Outline of a blacktip reef shark (20)
- ☐ Tagboard (20)
- ☐ Pencils
- ☐ Glue
- ☐ Scissors
- ☐ White copy paper or butcher paper
- ☐ Crayons (fat crayons work best)
- ☐ Colored pencils or markers

Setup:

1. Make copies of the blacktip reef shark outline.
2. Cut the sandpaper sheets in half. Ensure the size of the sheet is roughly the same size as the shark outline.

Procedure:

1. Talk to the students about the special skin of a shark.
   a. Shark skin sometimes feels like sandpaper because it has small rough placoid scales (also known as dermal denticles).
   b. Dermal denticles are similar in structure to teeth, and are what gives the skin a rough feeling.
   c. The scales point towards the tail and help make it easier for the shark to swim through water.
   d. Because of this, if someone rubbed the skin from the head towards the tail, it would feel very smooth. In the opposite direction it feels very rough like sandpaper.
   e. As the shark grows, the placoid scales do not increase in size, but rather the shark grows more scales.
2. Give each student an outline of a blacktip reef shark.
3. Remind students that they learned a bit about these sharks when they watched the *Hidden Pacific* documentary. Share some of the background information with the class and also ask for volunteers to share any blacktip shark facts they remember from the film.
4. Give each student a sheet of sandpaper, a pencil, and a scissors.

5. Instruct students to cut out their shark, and then trace the shape onto the smooth side of the sandpaper.

6. Next, they will cut out the sandpaper shark shapes.

7. Give each student a sheet of tagboard and have them glue down the smooth side of the sandpaper onto the tagboard. These are their shark masters.

8. Give each student a piece of white copy paper or butcher paper and a crayon.

9. Instruct them to place the paper over the shark masters and use the crayon to lightly rub over the shark masters.

10. The outline of the shark and the rough texture will appear on the paper, simulating the placoids or dermal denticals.

11. Students can then use the crayons, colored pencils, or markers to create habitats around their sharks. Encourage them to create habitats that they observed in the film.

Activity 2: Mark the Shark

Time: 30 minutes

Materials:

- ☐ Copies of the Mark the Shark worksheet
- ☐ Crayons
- ☐ *Sharkabet* book (*Sharkabet: A Sea of Sharks from A to Z* by Ray Troll)

Setup: None.

Procedure:

1. Read the book *Sharkabet* to the class.
2. Explain to students that just like other fish, sharks have fins that they use primarily for swimming.
3. Using the chondricthyans picture from *Sharkabet*, review with students the locations and functions of the various fins of a shark.
   a. The fins of sharks are used for stabilizing, steering, lift, and propulsion.
   b. Each fin is used in a different manner.
   c. Sharks have one or two dorsal fins that are used to prevent rolling and to help stabilize the organism.
   d. Pectoral fins originate behind the head and extend outwards. These fins are used for steering during swimming and help to provide the shark with lift.
   e. Pelvic fins are found underneath the shark, near the cloaca, and are also stabilizers.
   f. The tail region consists of the caudal fin. The caudal fin has both an upper and lower lobe that can be of different sizes and the shape varies across species. The primary use of the caudal fin is to provide thrust and propulsion while swimming.
4. Distribute crayons and copies of the Mark the Shark worksheet to the class. Point out that this is a picture of a blacktip reef shark.
5. Read students the following directions and allow them time to complete each step.
   a. Draw a circle around the caudal fin (tail).
   b. Draw a triangle on each dorsal fin.
   c. Make an arrow pointing to the pectoral fin.
   d. Put an X on the pelvic fin.
   e. Draw some dots on the anal fin.
   f. Count the number of fins you can see on the shark and write this number on your paper.

6. As the students complete each activity in Step 5, ask them to identify the main function of that fin.

7. As an extension activity, students can do additional research on blacktip reef sharks and add 3–5 new facts that they learn to their worksheet.

Mark the Shark

1. Draw a circle around the caudal fin (tail).

2. Draw a triangle on each dorsal fin.

3. Make an arrow pointing to the pectoral fin.

4. Put an X on the pelvic fin.

5. Draw some dots on the anal fin.

6. Count the number of fins you can see on the shark. Write this number here:

Activity 3: Fishing for Sharks

Time: 45–60 minutes

Materials:

- ☐ Bandanas or other strips of cloth
- ☐ Labels of name badges
- ☐ 6 nerf balls of other soft objects that can be thrown safely
- ☐ 3 12-ft long ropes or clotheslines
- ☐ 12 clothespins
- ☐ Notebook paper
- ☐ Copies of the Fishing Simulations Worksheets
- ☐ Whiteboard

Setup:

1. Before beginning the simulations, create a large open space in the middle of the room. (Or find an open space outside.)

Procedure:

1. Ask students if they know how people catch fish in the open ocean.
2. Have a few students share what they know, then discuss the following with the students:
   a. Sharks have been suffering from significant population declines. Scientists estimate that some species have declined by 50–75% in the last 20 years!
   b. One reason that shark populations have declined rapidly is because many common commercial fishing methods, such as drift net fishing, accidentally capture sharks when attempting to catch other fish the commercial fishing intended to catch. This is known as bycatch.
   c. Another reason researchers have seen declines is due to a growing market for shark meat, shark fins, and other shark products. This has made sharks a new target for fishers who previously weren't interested in capturing sharks, or at least didn't keep the sharks if they were caught. Blacktip reef sharks, like those featured in the *Hidden Pacific* documentary, are considered to be tasty and are often targeted for their meat and fins (which are used to make shark fin soup).
3. Tell students that the class will conduct a series of classroom exercises to show how various fishing methods are effective in catching their targeted species.
4. Write the following list on the board (if limited for time, feel free to choose 1–2 methods to focus on for the activity):

a. Hook and line

b. Gill nets and drift gill nets

c. Longlines

5. Tell the students that the first exercise will be a hook-and-line simulation.

   a. Explain to students that hook-and-line fishing is a method used by many fishers. In this simulation, some of the students will "fish" for yellowfin tuna using a hook and line. The other students are going to be the tuna, sharks, and other ocean organisms.

   b. Ask for 2–3 volunteers to be fishers. Have the fishers stand aside as you divide the remaining students in the class evenly into the following groups.

      i. 2–3 pairs of students with linked arms. Each pair will represent an adult tuna.

      ii. 2–3 individual students. Each student will represent a juvenile tuna.

      iii. Another 2–3 pairs of students with linked arms. These pairs will represent adult blacktip reef sharks.

      iv. Another 2–3 individual students. Each student will represent a juvenile blacktip reef shark.

      v. 1–2 students to serve as data collectors for the fishers.

      vi. All remaining students will represent other fish in the ocean.

   c. Give each student a label or name badge to write down the organism they will play.

   d. Explain the following rules to the class:

      i. The fishers will have one minute to fish for a tuna from the class "ocean."

      ii. They will fish by throwing the nerf ball (each fisher will have two) into the sea of fish from an assigned boat (desk) on the perimeter of the room.

      iii. None of the fish may run, but they can "swim" around the room quietly and calmly.

      iv. Any fish hit by a nerf ball is considered to be caught by the fisher who threw it.

      v. If the fish is not an adult tuna, the fishers should throw it back into the "ocean" and toss the ball again to continue fishing. Have any adult tuna that are caught stand next to the fishers who caught them.

      vi. Whichever fisher has caught the most adult tuna when the minute is over wins the round.

      vii. The data collector is responsible for recording the results of the fishers on Chart A of the Fishing Simulations Worksheet.

         1. Each data collector (if more than one) will be assigned to one fisher.

         2. The data collector must count EVERY fish that is caught, even if the fish is thrown back in.

   e. To begin the simulation, group the fish in the middle of the room and assign each fisher (and data recorder) to a boat (table) on the perimeter of the room.

      i. Set your timer to one minute and tell the fishers to begin.

      ii. The fishers are allowed to get up to retrieve their nerf balls, but remind them that they can only "fish" from their assigned "boats".

f. At the end of the simulation, ask the data collectors to place their information on the board. Instruct the other students to copy the data to their own worksheets.

g. Repeat the simulation one more time.

h. Discussion:

i. How many fish were caught that were not adult tuna?

ii. How many of those fish were sharks?

iii. What would happen in real life if these fish and/or sharks were caught, but then released?

1. Explain to the students that most fish and sharks are generally able to survive when they are caught using this method and then thrown back quickly.

6. The second exercise will be a gill net simulation

a. Explain to the students that some fishers use gill nets to catch fish in the open ocean. Gill nets allow a fish to fit its head and gill covers, but not its fins or other parts of its body, through the net holes.

i. The gill covers get caught in the net, preventing the fish from wriggling loose. Any fish that are larger at the gills than the holes in the net will get stuck.

ii. Once the net is pulled onto a fishing boat, the fish will quickly die. Many sharks are accidentally caught in gill nets by fishers who are targeting tuna.

iii. Some of these nets are fixed in one place and collect fish until they are hauled onto the boat. Others are allowed to float through the open water; these are called drift gill nets. Sometimes these drifting nets can get lost; they then float for years gathering fish and other organisms in them.

b. Select one student to be the fisher.

i. Have that person place the ropes down on the floor to create four equally spaced lanes.

ii. Instruct the fisher to secretly designate one lane as the location where the gill net will be and to tell you.

c. Divide the rest of the class as follows. Again, give them labels to write down their roles.

i. ¼ of the class will be adult tuna.

ii. ¼ of the class will be juvenile tuna.

iii. 1 student will represent a sea turtle.

iv. 1 student will represent a dolphin.

v. 4 students will represent small fish.

vi. ½ of the remaining students will represent adult sharks.

vii. The students left will represent juvenile sharks.

d. Gather the students at one end of the classroom.

i. Explain that they will have to walk to the other end of the room.

ii. When they get to the ropes, they each need to decide on one of the four lanes to walk down. Tell them that the fisher has placed a gill net across one of these lanes, but since they are fish, they cannot see it.

iii. Tell students that once they have chosen a lane, they cannot change their mind.

iv. The "organisms" should swim from one end of the room to the other and they should stay in their lanes at the other end of the room.

v. Once all the organisms have made the journey, the fisher will announce which lane had the gill net and will then count up his/her catch.

1. Any "small fish" or juvenile tuna would have been able to swim through the netting and not get caught. These fish are safe.
2. Any remaining organisms should be considered as caught.
3. Record these organisms on the Fisheries Simulations Worksheet on Chart B on the whiteboard.

e. Repeat the simulation one more time.

f. Instruct students to copy the data onto their own worksheets.

g. Discussion:

i. How are these results similar or different to the results documented in the first simulation (compare the results in Chart A to Chart B)?

ii. What conclusions can you make about gill net fishing from this simulation?

7. The third exercise is a longline simulation

a. Explain to the students that longlines are long, thin cables that stretch as far as 40 miles across the ocean.

i. The longlines are identified by a floats attached to the cable every few hundred feet.

ii. They also have a baited hook attached every few feet.

iii. Longlines are often used to catch tuna and large billfish, but they also unintentionally catch many sharks.

b. Select two students to be longline fishers.

i. Give them one rope, the clothespins, and 10 or more pieces of paper.

ii. Have them go out into the hall and clip the paper along the rope in whatever distribution they want.

iii. Tell them that they will learn how to "fish" with their longline when they get back into the room.

c. While the two fishers are out of the room, divide the group as follows, giving them labels to write down the identity they've been assigned:

i. ¼ of the class will be adult tuna.

ii. ¼ of the class will be juvenile tuna.

iii. 2 students will be sea turtles.

iv. 1 student will be a dolphin.

v. ½ of the remaining students will represent adult sharks.

vi. The remaining students will represent juvenile sharks.

d. Tell the fish to sit around the room in any configuration they want. The only thing they cannot do is sit directly behind another fish. Also, be sure that they are spread out throughout the room and not bunched up in one area of the class.

   i. Bring the two fishers back into the room and have them each stand at one end of the room with their rope stretched out across the classroom between them.

   ii. They should hold the rope in a way that so that the papers are at about head height.

   iii. Explain that the papers on their longline are meant to represent their baited hooks. If the "hooks" brush against one of the "organisms", they will be considered caught.

   iv. Ask all the "organisms" to stand up in the spots where they are sitting. Let them know that they are not allowed to duck or shift their bodies to avoid one of the "hooks".

   v. Instruct the fishers to walk slowly down the length of the classroom, being sure not to shift their longline to avoid hitting a particular fish.

   vi. Every time a fish is brushed by a piece of paper, that student should remove the paper, and then go to the front of the room. (Remind students that in real life, once a hook has caught a fish, no other fish can be caught on it.)

   vii. Record the fishing outcome on Chart C of the worksheet and write it on the board.

e. Repeat the simulation one more time with the organisms choosing different locations and the fishers adjusting the height of the line.

f. Discussion:

   i. How do these results compare to those seen in the first and second simulations?

   ii. What conclusions can you make about longline fishing?

8. Overall discussion:

   a. Ask the students if they have any questions about any of the simulations?

   b. What are some of the advantages for each of the fishing methods examined?

   c. What are the disadvantages of each method?

   d. If you were a fisher, which method would you use? Why?

   e. Were you surprised by how many sharks and other fish/organisms were caught, even though they weren't the targeted species?

   f. Why might some fishing methods present particular problems for many shark species, whether they are intentionally or accidentally caught?

   g. Can anyone think of any solutions or techniques to help reduce the amount of bycatch that is seen in the fishing industry?

Fishing Simulation Worksheet

Record the fishing results for each of the following methods. Adult tuna is the intended target for each method.

Chart A: Hook and Line

	Adult Tuna	Juvenile Tuna	Adult Shark	Juvenile Shark	Other Fish
Round One					
Round Two					

Chart B: Gill Nets

	Adult Tuna	Juvenile Tuna	Adult Shark	Juvenile Shark	Sea Turtle	Other Fish
Round One						
Round Two						

Chart B: Gill Nets

	Adult Tuna	Juvenile Tuna	Adult Shark	Juvenile Shark	Sea Turtle	Other Fish
Round One						
Round Two						

MANTA RAYS

Manta rays in Palmyra Atoll National Wildlife Refuge. The pattern of spots found on the underside of manta rays are unique to each individual and can be used for identification.

Image courtesy of *Hidden Pacific*

MANTA RAYS

Overview: Students will learn about the basic physiology of manta rays as well as how they feed and their role in the ecosystem/food chain.

Grade Level: 4th–5th grade

Next Generation Science Standards:

› **5-LS2-1:** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

› **5-ESS3-1:** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

› **4-ESS3-2:** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Objectives:

Students will be able to:

› Identify manta ray adaptations.

› Model how manta ray feed and make observations on the role that cephalic lobes play.

› Recreate a manta ray food chain.

› Discuss how changes in manta ray prey and predators can impact their survival.

Time: 60 minutes

Background Information:

Manta rays are huge fish that can weigh up to 3,000 lbs., with wingspans reaching around 20 ft. Like sharks, manta rays also have a cartilaginous skeleton. Manta rays have distinct features called cephalic flaps at the front of their mouths that funnel water towards their mouths. These flaps can curl up and resemble horns. This makes them the only vertebrate with three paired appendages.

The cephalic flaps allow manta rays to feed on large amounts of zooplankton at one time. Swimming in large loops or creating feeding chains with other mantas, they are able to maximize their prey intake by holding their cephalic fins in an "O" shape and opening their mouths wide in order to funnel water over their gill rakers. Mantas can also hunt at a variety of depths; they have been seen feeding in water as shallow as a few feet and as deep as 3,000 ft.

Mantas have two large pectoral fins located on the sides of their bodies. They flap these fins like wings in order to "fly" through the water. Their gills are located under their body and their mouths are directly in front of them. They have a long dorsal fin near the base of their tail. Their tails are flattened, indicating that they do not have a poisonous stinger. Mantas have rough skin that is covered in a mucus layer for protection.

Activity 1: Manta Ray Feeding

Time: 30 minutes

Materials:

- ☐ Large bins of water (5)
- ☐ Nets (10)
- ☐ Pieces of plastic to attach to nets (10)
- ☐ Zip ties (20–30)
- ☐ Single hole punch
- ☐ Wooden bingo balls/beads—need to float (60)
- ☐ Whiteboard (1)
- ☐ Expo markers (2)
- ☐ Manta Ray Feeding Data Sheets (5)
- ☐ Pencils (20)
- ☐ Paper
- ☐ Tape

Setup:

1. Create cephalic lobes, by adding two pieces of plastic around the opening of a net.
    a. Use the hole punch to add holes to one edge of the pieces of plastic.
    b. Slip the zip ties through the holes and attach the two pieces of plastic to the net.
    c. Create four more and set these nets aside.
2. Set up five tables in a classroom with bins of water.
    a. Place 15–20 wooden beads in each bin.
    b. Place a regular net at each table along with one data sheet and a few pencils.
3. Print or write the following terms on individual squares of paper:
    a. Pectoral fin
    b. Dorsal fin
    c. Tail
    d. Gills
    e. Cephalic lobes

4. Set up the whiteboard as follows:
   a. Draw an outline (or print a large picture) of a manta ray. Include pectoral and dorsal fins, tail, gills, and cephalic lobes.
   b. Write cartilaginous skeleton, zooplankton, and hydrodynamic on the board as terms to define later.

Procedure:

1. Ask the students what they can recall about manta rays from the *Hidden Pacific* film.
2. After having a few students share their thoughts, point out the terms on the board, define them as a group, and discuss how the terms are related to manta rays.
   a. Cartilaginous skeleton: a skeleton made of cartilage instead of bone. Manta rays have cartilaginous skeletons like sharks.
   b. Zooplankton: plankton (small, microscopic organisms drifting or floating in water) consisting of small animals or the early life stages of large animals (examples are copepods, jellies, larval fish, etc.). Manta rays feed on large quantities of zooplankton through a process called filter feeding.
   c. Hydrodynamics: the study of fluids and how objects act in fluids. Manta rays are considered to be very hydrodynamic because their bodies are incredibly well designed for gliding or "flying" through the water.
3. Ask for a couple volunteers to help label the drawing of the manta ray on the board.
   a. Give each volunteer one of the paper squares with an anatomical term and have them tape the term on the part of the manta ray they think it represents.
   b. When a term is placed correctly, ask the students to describe how that part is used by the manta ray. Responses should include the following:
      i. The pectoral fins are like wings and help them swim.
      ii. Gills help them breathe.
      iii. The tail helps stabilize them.
      iv. Cephalic lobes help them eat by funneling water into their mouths.
      v. The dorsal fin is also for stabilization.
4. Explain to the class that they will now simulate how manta rays eat.
5. Split the class into five groups and assign each group a table to work at.
6. Instruct the students that within their groups, they will take turns sweeping the net from one end of the bin to the other end to try to catch the wooden beads.
   a. Each student should do one swipe each.
   b. After each swipe, the student should count how many beads are in their net, record the number on the data sheet, and return the beads to the bin.
   c. Repeat until each student has had a turn.

7. Once each student has had a turn, ask each group to share some observations about how the net worked to “capture” the beads.

8. Now, give each group a net with the plastic additions. Instruct the students to repeat their “feeding” procedure done in Step 6.

9. Ask students to share their observations. Use the following as guiding questions:

   a. How did the number of beads captured with the second net compare to the number of beads captured with the first net?

   b. Why do you think there was a difference?

   c. How do the modified nets compare to the anatomy of a manta ray? What structures do the plastic additions represent?

   d. Why might this be an important adaptation for manta rays?

10. After allowing students to share their thoughts, explain that the plastic pieces represent the cephalic flaps of the manta ray. The flaps help to funnel large amounts of water towards the manta ray’s mouth allowing them to catch more zooplankton. This is how manta rays are able to survive off of such small organisms—by maximizing the amount of water they can filter, they can capture a larger quantity of food!

11. If time permits, show students the following video: https://www.youtube.com/watch?v=5I_I5H20-yE

Manta Ray Feeding Data Sheet

Student Name	Trial 1 # of beads	Trial 2 # of beads
Observations:		

Manta Ray Feeding Data Sheet

Student Name	Trial 1 # of beads	Trial 2 # of beads
Observations:		

Activity 2: Manta Ray Food Chain Blob Tag

Time: 30 minutes

Materials:

- ☐ Different colored string or fabric (green – 12, blue – 5, red – 6, yellow – 1)
- ☐ A large, open space to spread out (a gym, playground, etc.)
- ☐ Brown paper lunch bag (1)
- ☐ Optional: cones (4–8)

Setup:

1. Cut the string or fabric into strips, long enough to be tied to a student's wrist or around their head (increase the number of plankton for groups larger than 20).
   a. 12 green (zooplankton)
   b. 5 blue (manta rays)
   c. 6 red (sharks)
   d. 1 yellow (the sun)
2. Place all the strips into the paper bag except for four red strips. Set these four strips off to the side.
3. If using cones, set the cones up in the open space to create a defined boundary for the game. Keep the area spacious, but not too large as students will be tagging each other.

Procedure:

1. Ask students to describe a basic food chain.
   a. They should be able to outline the following: producers are eaten by herbivores (prey) which are eaten by carnivores (predators).
2. Review the terms food chain and trophic levels with the group using the following information:
   a. The food chain consists of trophic levels, or the levels within the food chain in which energy is transformed.
   b. A food chain illustrates one path through which energy and nutrients can flow through an ecosystem.
      i. Each level has one organism; it begins with one primary producer (an organism that creates its own food) and ends with a secondary or tertiary consumer (organisms that eat other things).
      ii. A typical food chain might go like this: algae-copepod-fish-squid-seal-orca. In this example the orca feeds on the seals and the seals feed on the squid, which feed on fish, which feed on copepods. The base of the food chain is formed by algae, which gets energy from the sun to make its own food, and is then eaten by copepods.

    c. Trophic levels in the ocean typically begin with phytoplankton, a primary producer capable making its own food from the sun.
    d. Primary consumers are in the second level because they only eat primary producers. These are organisms like zooplankton, larvae, sea stars, and some fish.
    e. Those that eat primary consumers are referred to as secondary consumers, and those that eat secondary consumers are known as tertiary consumers.
    f. The next level contains things that eat the organisms below it. These are fourth-order consumers. If nothing else eats it, it can also be called an apex predator. Sharks are examples of apex predators in the marine environment.
    g. The more trophic levels present, the less energy is conserved at higher trophic levels. (Meaning, the higher up you are on the pyramid, the more food you need to eat to get the energy you need.)

3. Explain to students that the example you gave them earlier (algae-copepod-fish-squid-seal-orca) was a food chain.

4. Ask students to think back to the previous activity where they modeled how manta rays feed. Where do they think the zooplankton and the manta rays are in the food chain?
    a. After hearing a few responses, share that zooplankton are first level consumers and because manta rays eat them, the mantas are secondary consumers. Mantas are not often preyed upon but sometimes sharks will eat them.
    b. Ask the student: Where would sharks be in the food web? (Tertiary consumers or apex predators.)

5. Let the students know that in the next activity, they will play a game that will help to demonstrate a manta ray food chain.

6. Relocate the group to an open space. Have the students stand or sit in a circle to explain the game.
    a. Let them know this game will be similar to blob tag.
    b. Point out the boundaries for the game.
    c. Explain that each student will select a piece of string or fabric from the bag and the color will identify which organism they represent.
        i. Green = zooplankton
        ii. Blue = mantas
        iii. Red = sharks
        iv. Yellow = sun
    d. Once each student has selected a string, give them the following rules:
        i. Zooplankton cannot tag anyone and can only be tagged by mantas.
        ii. When a zooplankton is tagged by a manta, they will link arms and work together as that manta continues to look for other zooplankton to tag.

iii. Mantas can tag zooplankton or be tagged by sharks. Any manta who tags a zooplankton or is tagged by a shark must link with that person.

iv. Sharks can only tag mantas (including mantas already in "blobs" with zooplankton).

v. The sun can tag any "blob" and break them up or "decompose" them so they can separate and rejoin the game as individuals.

7. Play one round of the game for three minutes. At the end of the round, have students describe what they observed occurring during the game.

8. Explain to the students that in round two, they will switch up the numbers a bit. Select four "zooplankton" volunteers and convert them to "sharks" with the remaining four red strips. Play round two for three more minutes.

9. At the end of the round, ask students to discuss what they observed happening with the food chains when we decreased the number of prey and increased the number of predators. Could this happen in nature?

10. Play one more round, this time cutting the number of zooplankton in half.

    a. At the end of the round, discuss with the students what the result of this action was.

    b. Could this happen in nature?

    c. How?

    d. Responses and discussion could include:

        i. Slow growth rate

        ii. Low birth rate—manta rays typically only give birth to one pup every 2–3 years.

        iii. Overfishing—manta rays are targeted in many global fisheries; they are also frequently caught as bycatch in fisheries that use large nets like purse-seines or gill nets.

11. Explain that manta rays are listed as a threatened species. A threatened species status means they are likely to become an endangered species in the foreseeable future. Threatened species receive extra protections to ensure their survival.

12. As a homework assignment, have students research the threats to manta rays and the strategies being used to help protect them.

SEABIRD BEAK ADAPTATIONS AND THE IMPACT OF PLASTIC POLLUTION

Layson albatross and their chicks nesting on Midway Atoll within the Papahānaumokuākea Marine National Monument. Albatross chicks are completely dependent on their parents for the first 6 months of their lives.

Image courtesy of *Hidden Pacific*

SEABIRD BEAK ADAPTATIONS AND THE IMPACT OF PLASTIC POLLUTION

Overview: Students explore seabird anatomy by taking a closer look at variation in beak size and shape to assess the role that different beaks have on the foods that seabirds eat. Students will also model how plastic and food can be eaten by seabirds and the impacts caused by digestion pollution.

Grade Level: 2nd–3rd Grade

Next Generation Science Standards:

› **2-LS4-1:** Make observations of plants and animals to compare the diversity of life in different habitats.

› **3-LS3-2:** Use evidence to support the explanation that traits can be influenced by the environment.

Objectives:

Students will be able to:

› Identify seabird beak adaptations.

› Experiment with different beak shapes differently in order to feed on different types of prey.

› Model how plastics can accumulate in the stomachs of seabirds over time.

› Describe the impact of pollution on albatross and other seabirds.

Time: 60 minutes

Background Information:

The Pacific Remote Islands Marine National Monument (PRIMNM) is composed of a diverse ecosystem that includes 14 million seabirds (from 21 species). The islands serve as nesting and resting habitats for millions of seabirds and migratory shore birds, such as red-footed boobies, sooty terns, Laysan and black-footed albatross, and many others. Jarvis Island alone is home to an estimated 1 million sooty terns and Palmyra Atoll is home to the second largest red-footed booby breeding colony in the world with an estimated 6,250 breeding pairs.

Seabirds have several adaptations, or traits, that help them to survive, especially for life at sea. Their wings can be long for pelagic species that fly great distances, shorter for those that are diving species, and most have webbed feet for better propulsion while on the surface of the water or for diving into the water. Most seabirds also have salt glands that allow them to excrete excess salt that they consume by eating and drinking from a saline environment (i.e., saltwater).

Seabirds have three primary methods of feeding: surface feeding, pursuit diving, and plunge diving. Some seabirds, such as frigatebirds, also get some of their food by stealing it from other birds. Seabirds also have specialized beaks based on their method of feeding and on what they eat. Most seabirds have beaks that they use to scoop or grab prey.

Many seabirds are increasingly having a harder time finding food and are eating trash or bringing the trash to their chicks. Albatross are severely prone to this due to their feeding behavior and where they spend most of their time. Albatross use their beaks to skim along the surface of the ocean for food. Along the way they pick up small pieces of plastic, called microplastics, which they either mistake for food or can't see because the plastics are so small. Because plastics cannot be digested by seabirds, they build up in their stomachs over time and chicks and adults cannot get the nutrients they need to survive.

Scientists are beginning to learn more about how eating plastics can prevent healthy digestion, cause dehydration, and increase pollutants in a seabird's body. Seabird boluses are dissected to learn what they are eating and to study if the amount of plastic trash is increasing in the ocean. For this reason, albatross and other seabirds are ideal sentinels, or bio-indicators, of the health of the ocean because they travel across the ocean and sample marine debris along their journeys. By tracking their movements and dissecting their boluses, scientists are learning about albatross plastic ingestion.

Activity 1: Bird Beak Adaptations

Time: 20–30 minutes

Materials:

- ☐ Tweezers (enough for 1/3 of class)
- ☐ Spoons (enough for 1/3 of class)
- ☐ Forks (enough for 1/3 of class)
- ☐ Trays or shoeboxes (4–5, one per group of six students)
- ☐ Random assortment of objects (can be anything)—enough to fill half of each box or tray
    - o Beads
    - o Craft pom poms
    - o Foam cut out pieces
    - o Beans
    - o Pieces of string
    - o Crayons
    - o Rice
    - o Small toy animals
- ☐ Cups (1 for each student)
- ☐ Stopwatch
- ☐ Pictures of different types of bird beaks (birds can include an albatross, brown booby, seagull, pelican, etc.)
- ☐ Data sheets

Setup:

1. Set out one tray/box for every group of six students.
2. Place two tweezers, two spoons, and two forks next to each box.
3. Print one data sheet (two pages, back and front) per student.
4. Fill each box halfway with your assortment of objects.
5. Create a large bar graph template on the board to help track the type of food eaten by beak type.

Procedure:

1. Ask students why birds have beaks. What do they use them for? Do all birds have the same beaks? Why might they have different beaks?

2. Introduce the term "adaptation".

3. Ask the students to share other adaptations they can think of. What adaptations did they notice while watching the *Hidden Pacific* film?

4. Show students the pictures of the birds. Ask the following:
   a. What do they notice about the beaks?
   b. What do they think the bird eats?
   c. How can we tell?

5. Tell the students that today they are going to explore bird beak adaptations by pretending to be feeding birds. Show students the trays of random objects and explain that each item represents a different type of food to birds. Maybe brainstorm with the students what each item could represent in real life (string could be worms, small toys could be fish, bead could be small shrimp in the ocean).

6. Show students each tool that they might get to use.
   a. Remind the students that birds can use their beaks as a tool.
   b. Each tool will represent different beak types. Ask students to hypothesize how they think each tool might be used as a beak. Responses can include the following:
      i. Spoon—for scooping up organisms
      ii. Tweezers—for picking up tiny organisms or getting into tiny spaces where organisms might hide
      iii. Forks—for spearing fish

7. Tell students that everyone will get a different beak type and will have 30 seconds to eat as much "food" as they can by picking or scooping up the objects and placing them in their cups (stomachs). After each round we will take note of what we ate and then switch beak types.

8. Divide students into groups of six and assign them a tray. Divide out which tools each student will start with. Make sure that at least one student in each group has a tweezer, spoon, and fork.

9. Start time and give students 30 seconds to eat as much food as they can.

10. Once time is called, have the students carefully make piles of the different food that they ate. Each student should use the data sheet to create a bar graph that shows how much of each food item was collected by their tool.

11. Instruct students to return the items to the bins, shake the bin gently to mix the items up, and trade beak types.

12. Repeat steps 9 and 10 until each student has had the chance to use each beak type at least once and they have created three graphs each. Have students carefully place their items back into their trays after each repetition.

13. Ask for a couple of volunteers to share their graphs. What patterns do they notice between the different tools? Take a few responses.

14. Show the pictures of the birds again. Ask the following:

    a. Which bird's beak do they think each tool might be modeling? (Spoon could be like a pelican, a bird that scoops its food; tweezers are like an albatross, which snaps up food at the surface of the water; etc.)

    b. Why do they think that?

Bird Beak Adaptation – Data Sheet

Student Name:

Tool (circle one): Spoon Fork Tweezers

Amount of Food Item Collected

Food Item

Tool (circle one): Spoon Fork Tweezers

Amount of Food Item Collected

Food Item

Tool (circle one): Spoon Fork Tweezers

Answer the following questions and discuss with your group:

1. What did you observe?

2. What patterns do you notice between the different tools?

3. Why do you think this is?

4. Which bird’s beak do you think each tool might be modeling?

Activity 2: Seabird Feeding and Plastic Pollution

(Adapted from the Alaska Department of Fish and Wildlife's "Feeding Frenzy" Activity)

Time: 30 minutes

Materials:

- ☐ Trays or shoeboxes (1 for a group of 4–5 students)
- ☐ Cups (1 for each student)
- ☐ Stopwatch (1)
- ☐ Plastic foam packing peanuts (½ cup per tray)
    - o Can substitute ½ cup per tray of craft pom poms
- ☐ Popcorn (1 ½ cup per tray)
- ☐ Spoons (1 per student)

Setup:

1. Fill trays or shoeboxes with the plastic foam packing peanuts and popcorn.

Procedure:

1. Tell students that now that we have explored bird beak adaptations, let's think about the albatross again. You can ask what things they remember about the albatross from the movie. Take some time to brainstorm what kind of things albatross eat.

2. If they are eating small things in the ocean ask if they think these birds could accidentally eat garbage by mistake. Tell them that we are now going to explore what it would be like to be an albatross trying to find food. This time we are all going to use spoons as our beaks!

3. Divide students into groups of 4–5 again and give each student a cup (stomach) and a spoon (beak).

4. Give students 30 seconds to scoop as much food from their bins into their stomachs as possible without throwing the food into the cup, only scooping.

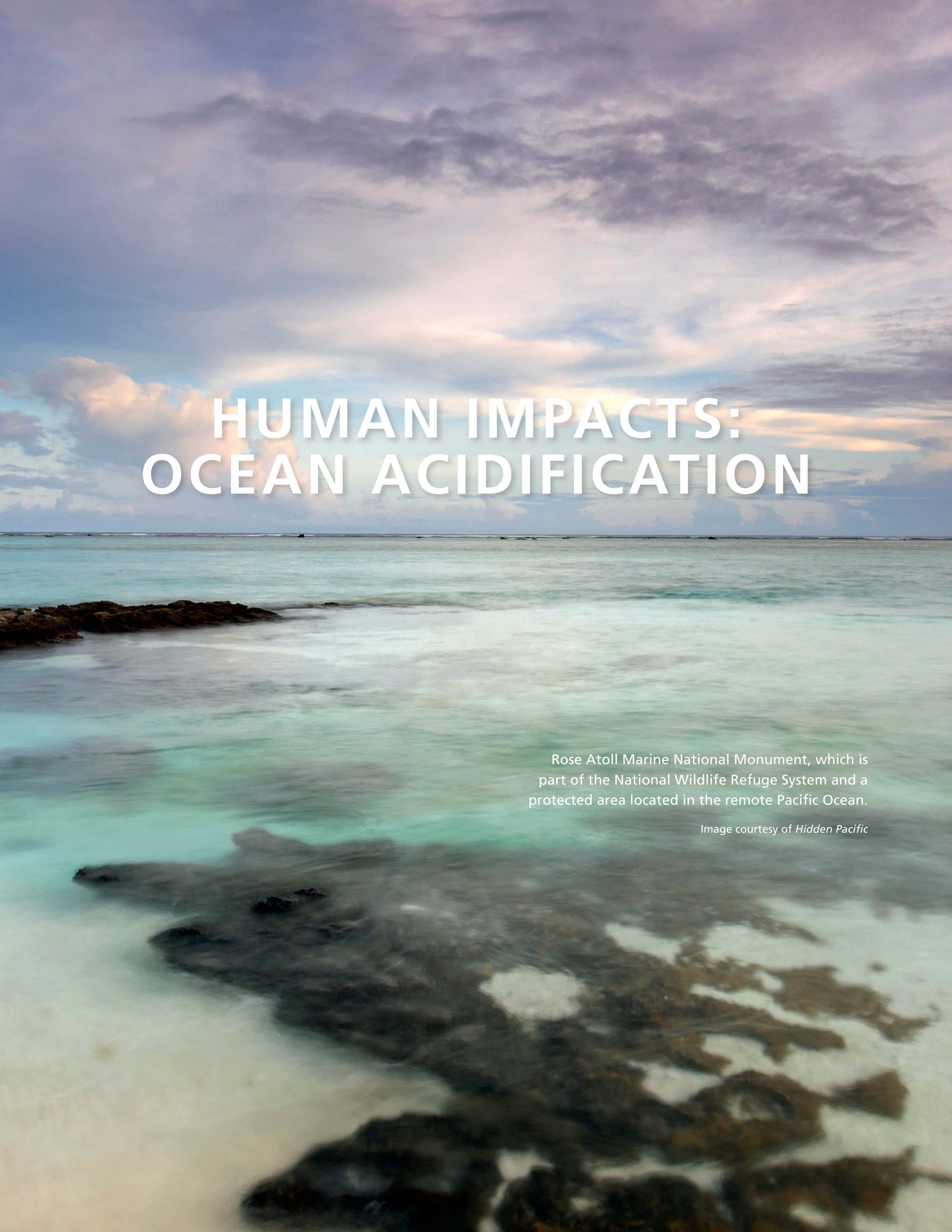
5. After 30 seconds, have students count how many pieces of popcorn they have and how many pieces of packing peanuts. Students should create their own graph to help them track this over time.

6. Have students put the popcorn back into the bin but the packing peanuts have to stay.
    a. Why do they think the packing peanuts must stay in the cups?
    b. Remind them that the cups represent the stomach of the bird and plastic cannot be digested by the bird.

7. Repeat this 30 seconds of eating and counting for a few rounds.

8. What do the students notice happening in their “stomachs”?
   a. Students should observe that as they keep feeding, they keep selecting plastic because it looks so similar to their main food item.
   b. Students should also observe that over time, the plastic in their “stomach” continues to accumulate.
9. Ask the students, What does this mean for albatross in the wild? Student responses should include:
   a. The birds cannot eat other food that helps them get nutrients and energy.
   b. The birds may become ill because they can’t get rid of the plastics in their bodies.
10. Have students brainstorm ways that they can use less trash and plastic in their lives and what they could tell their friends and families to do to help the albatross.
   a. For kids, great ideas would be: I will recycle; I will make sure my trash ends up in the garbage at lunchtime; I will ask my adult to pick up trash and throw it away if we see it on walks; etc.

HUMAN IMPACTS: OCEAN ACIDIFICATION



Rose Atoll Marine National Monument, which is part of the National Wildlife Refuge System and a protected area located in the remote Pacific Ocean.

Image courtesy of *Hidden Pacific*

HUMAN IMPACTS: OCEAN ACIDIFICATION

Overview: Students learn about the effects of ocean acidification on Pacific Ocean atolls and coral reefs.

Grade Level: 6th–8th grade

Next Generation Science Standards:

- **MS-ESS3-2:** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects
- **MS-ESS3-5:** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century
- **MS-LS1-4:** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively
- **MS-LS1-5:** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
- **MS-LS1-8:** Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories
- **MS-PS1-1:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred
- **MS-LS2-4:** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

Objectives:

Students will be able to:

- Define ocean acidification.
- Discuss anthropogenic causes of ocean acidification and effects of ocean acidification on atolls and coral reefs.
- Describe the effects of rising sea temperatures and ocean acidification on delicate ecosystems such as atolls and coral reefs.
- Reflect on what make atolls and coral reefs such unique, diverse, and protected ecosystems.
- Discuss strategies for helping to address the impacts of ocean acidification.

Time: 60 minutes

Background Information:

The burning of fossil fuels like coal, oil, and gas releases carbon dioxide (CO_2) into the atmosphere. The more fossil fuels we burn, the more CO_2 is emitted into the atmosphere. This added CO_2 acts like a heat-trapping blanket, holding in heat that would normally escape. As we add CO_2 to the atmosphere, this blanket gets thicker and the temperatures of the Earth and ocean increase as well. Increasing temperatures on Earth and in the ocean create changes in global weather patterns and produce stressors on flora and fauna that cannot adapt as quickly as temperatures are changing. Another major effect of increasing CO_2 is the phenomenon of ocean acidification.

Ocean acidification occurs when excess carbon dioxide gas is produced when humans burn fossil fuels such as coal and gas. This excess CO_2 mixes with seawater, forming carbonic acid (H_2CO_3) and lowering the pH of the water. This is the process we call ocean acidification. This process changes the pH and makes the water more acidic. This process has been accelerating on Earth ever since the Industrial Revolution (when we started using fossil fuels) and it has increased the acidity of the ocean by 30% in just 200 years! It is predicted that continued burning of fossil fuels, like coal and oil, will increase the amount of carbon dioxide in the atmosphere and ocean to such high levels that by the end of the century it will cause the pH to decrease to levels the global ocean has not experienced in millions of years.

Corals, pteropods, and other marine organisms have shells or skeletons made of calcium carbonate ($CaCO_2$). They draw $CaCO_2$ directly from the water to help build these structures. As the waters become more acidic, the extra hydrogen ions (H+) trap the $CaCO_2$, making it unavailable to the organisms. The result is weakened and deformed shells or slower growth rates.

Hard corals (the reef-building corals) and their skeletal structures are composed of calcium carbonate. In order to build their skeletons, corals must have access to available calcium in the seawater. This is especially true in the early stages of a coral polyp's life. Research has shown that ocean acidification has had a negative impact on the rate at which corals calcify, meaning that in the future, coral colonies may become more brittle and less resilient to other factors that impact survival. This may have detrimental effects to coral communities, even for corals in protected areas like those found in the Pacific Remote Islands Marine National Monument.

Activity 1: Carbon Sources and Sinks

Time: 30 minutes

Materials:

- ☐ Pictures of carbon sources (cars, factories, etc.)
- ☐ Pictures of carbon sinks (the ocean, trees, etc.)
- ☐ Carbon source page (below)
- ☐ Carbon sink page (below)
- ☐ Small mirror
- ☐ Cups or small beakers (10)
- ☐ Cardboard/paper straws (10)
- ☐ Phenol red powder
- ☐ Fresh water
- ☐ Phenol red scale (10)
- ☐ Large jar or beaker (1)
- ☐ Distilled water
- ☐ Spoon or stirrer (1)
- ☐ Scissors (1)

Setup:

1. Place the carbon source and carbon sink pages on the table or tape to the board/wall.
2. Create phenol solution:
   a. Place a scoop of the phenol red powder into the large jar and add distilled water.
   b. Mix well.
   c. Distribute the solution among the 10 cups.
3. Cut the paper straws in half.
4. Make 10 copies of the phenol red scale.

Procedure:

1. Ask students if they know some of the impacts of CO_2.
   a. Take a few answers.
   b. Students may mention climate change. If they do, briefly explain how the increased levels of CO_2 create a "heat trapping blanket."

2. Introduce the term "ocean acidification" and explain how the dissolving of CO_2 into sea water makes it more acidic.

3. Ask students: Where does carbon dioxide come from?
    a. Introduce the term fossil fuels and some of the sources. These are known as carbon sources.
    b. Discuss: How have humans contributed to the production of excess carbon?

4. Ask students: Where do you think CO_2 ends up once it is produced?
    a. Explain that anything that absorbs carbon is called a carbon sink. Carbon sinks are natural systems that suck up and store carbon dioxide from the atmosphere.
    b. Discuss different types of carbon sinks, such as forests, oceans, soil, etc.

5. Test the students' understanding by showing them the carbon source and sink pictures one at a time.
    a. Ask them to determine whether the photo should be placed on the sink pile or source pile.
    b. Once they have chosen, let them know if they were right or wrong and share some additional information about the picture.

6. Once all the pictures have been placed, show them the mirror and ask: Are you a carbon source or sink?
    a. Remind them that we are also sources of CO_2.
    b. Not only do we breathe out CO_2 due to the process of respiration, we help release CO_2 from other sinks.

7. Restate the process of ocean acidification:
    a. Explain that it occurs when CO_2 is dissolved in seawater and it mixes with the water to create carbonic acid.
    b. This process makes the water more acidic by decreasing the pH.

8. Let the students know that we can test this idea with a simple experiment.

9. Place students into pairs and give each pair a phenol red scale.

10. Show the students a cup with the phenol red solution.
    a. Explain that this cup contains water and a pH indicator, something that helps us to determine the pH of a solution by changing color.
    b. Ask them to use the scale to ID the current pH of the liquid in the cup.

11. Now, give each pair a cup and two straws.
    a. Ask students: Where can we get some CO_2 for our experiment?
    b. Remind the students that we are sources of CO_2, because we breathe it out through the process of respiration. (This is the opposite of photosynthesis.)

12. Instruct the students to take turns using the straw to gently blow bubbles into the cup. What do they observe happening? (The liquid should start changing color as the pH drops.)

13. Lead a short discussion with the group using the following as guiding questions:
   a. What did you observe? What happened to the liquid in the cup?
   b. Why?
   c. How does this experiment compare to what is occurring in our oceans?
   d. In this experiment, the CO_2 came from us. What are some of the other sources of CO_2 in nature?
   e. Are there ways that we can help decrease or eliminate these sources?

CARBON SINK

Anything that absorbs more carbon than it releases.

CARBON SOURCE

Anything that releases more carbon than it absorbs.

Activity 2: The Impact of Ocean Acidification on Marine Organisms

NOTE: If you are doing Activity 1 and 2 on the same day, you can set up Activity 2 first and start the experiment before you begin Activity 1. Then, as you move through Activity 1, take a few pauses during the activity to have volunteers weigh the shell following the Activity 2 instructions below in Step 5. After Activity 1, you can transition straight into this activity by beginning at Step 6 below, exploring the data that has been collected so far.

Time: 30 minutes

Materials:

- ☐ Large shell
- ☐ Vinegar
- ☐ Small towel
- ☐ Bowl large enough to hold shell
- ☐ Scale
- ☐ White board or chart paper

Setup:

1. Create a chart on the white board or chart paper with the following columns:
   a. Time
   b. Mass of shell
2. Tare/zero out the scale.
3. Weigh shell and record its mass, along with the time, in the first row of the column.
4. Place shell in a bowl and cover with vinegar. Set aside.

Procedure:

1. Review with students what happens when CO_2 is absorbed into the water.
   a. Increased use of fossil fuels have released more CO_2 into the atmosphere.
   b. Much of this CO_2 is dissolved into the ocean and mixes with the water to create carbonic acid (H_2CO_3).
   c. This increases the acidity of the water (ocean acidification).

2. Explain that this change in the pH of the water can have a negative impact on some marine organisms.
   a. Those organisms that have shells or skeletons made of calcium carbonate ($CaCO_2$) are affected the most. These include clams, oysters, shrimp and lobster, pteropods, some plankton, and corals.
   b. The increased carbonic acid creates lots of extra hydrogen ions, which trap the $CaCO_2$.
   c. This makes it difficult for the organisms to continue making their shells or skeletons.
   d. It causes the shells to become weakened and/or deformed. And in some cases, it slows their growth rates.
3. Tell students that the next experiment will explore this.
4. Direct their attention to the shell in the bowl of vinegar.
   a. Explain that vinegar is a weak acid.
   b. Ask the students to look closely at the shell in the container. What do they see?
      i. They should notice some bubbles coming off the shell. What is this?
      ii. Explain that the bubbles are CO_2 escaping.
5. Ask the students if they'd like to add to the data.
   a. Have a volunteer take the shell out of the vinegar, dry it off gently with the towel, and place it on the scale.
   b. Ask the student to record the time and mass on the board.
6. What do they notice based on the data that has been collected so far today?
7. Explain that what we are seeing is the dissolution of the calcium carbonate shell due to the acidity of the vinegar.
8. Ask students if they can think of any other marine organisms that might be impacted by ocean acidification in this way. After collecting a few responses, share the following examples of the detrimental effects of ocean acidification on the marine ecosystem.
   a. The shells of pteropods dissolve away in sea water with lower pH. These pea-sized organisms are a major food source for other zooplankton, whales, and North Pacific juvenile salmon.
   b. Low pH waters have contributed to the failure of developing oyster larvae in natural areas on the west coast.
   c. Increasing ocean acidification has been shown to reduce the ability of reef-building corals to produce their skeletons. It also is believed to severely impact the ability of coral reefs to recover from disturbances.
   d. It is currently impossible to predict exactly how ocean acidification impacts will cascade throughout the marine food chain and affect the overall structure of marine ecosystems.

9. Lead a discussion using the following questions:
   a. How do you think ocean acidification might impact protected areas like the Pacific Remote Islands Marine National Monuments?
   b. Humans play a large role in creating sources of carbon dioxide. What can you and your community do to help reduce these sources?

10. Potential extensions:
   a. Students can do further research to learn more about the other examples of the detrimental impacts of ocean acidification that they heard about earlier and present their findings to the class.
   b. Students can investigate and calculate their carbon footprint individually, as a family, and as a community.