

100 STEM Taught®

PALU, MAN OF THE SEA

STEMTAUGHT



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This story was inspired by the work of One People One Reef and communities on Ulithi Atoll through their storytelling project, and "The Bottomless Clam Shell" written by Emma Lassiter in collaboration with the team.

This book aligned with the Next Generation Science Standards (NGSS). The Next Generation Science Standards (NGSS) are reproduced with permission from the Department of Education.

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Palu, Man of the Sea

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5-ESS3-1 Earth and Human Activity: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. **3-5-ETS1-1 Engineering Design:** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.



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On a coral reef far, far away...

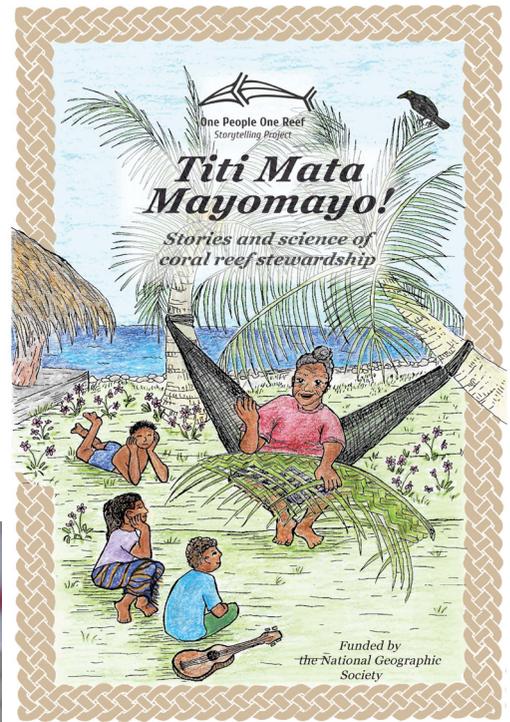
What does story telling have to do with protecting the environment? Islanders who live on the Ulithi Atoll in the Pacific Ocean might say, "A lot!" People on the Ulithi Atoll noticed that their coral reefs did not look as healthy as they used to. They were catching smaller and fewer fish, and nobody was sure why. The islanders invited scientists to visit their atoll to study their reefs. The research found that overfishing and climate change were the two biggest influences hurting the health of their reef.



Giant clams can live to be more than 100 years old. Islanders, the islanders grow the clams in "gardens," harvesting some for food while helping others reproduce!

Together, the scientists and the islanders came up with a plan to improve the health of the reef. They all collected data together. Community leaders and youth would educate fellow islanders on how to care for the reef through storytelling. Today, when Ulithian elders share their island's legends, they are educating a new generation of islanders on how to best protect their precious reef ecosystem.

With a project called, “One People, One Reef,” there has been a renewed effort from the community to record and share the stories of their ancient culture. Children know that they are not only listening to fun fables—they are also learning how they can care for the environment! Some of these children are now in college learning more about how to protect their reef.



Credit: Katie Sugarman

The Ulithian title of this book of traditional stories translates as, “Wake up, sleepyhead!”



Credit: Katie Sugarman

Children listen to stories as they are recorded for preservation.



Photo credit: Scott Davis

Local girls read traditional stories about how to protect the reef on an iPad.

This story is patterned after traditional Ulithian storytelling. It contains Ulithi culture and science findings that teach what is hurting the health of the Ulithi reef and island ecosystems.

Watch for these animals in the story

Read the story to see which native animals are naturally found on the islands and which invasive animals were introduced to the islands by humans. Mark them here.

WOOL Native
Green Sea Turtle Invasive



The green sea turtle migrates long distances between feeding grounds and hatching beaches. Many turtles return to nesting on the beaches of islands in the Ulithi Atoll. Females crawl onto the beach, dig a nest, and lay their eggs during the night. Later, hatchlings emerge from the sand and scramble into the water. Green Sea Turtles can live up to 90 years.

GIIT Native
Octopus Invasive



The octopus commonly thought of as the most clever invertebrate animal. Invertebrates do not have a spine or any bones. The octopus is very curious and can even be playful. Ulithians believe that some clans, or families, of the Ulithi atoll descended from the clever octopus.

HALIIVF Native
Monitor Lizard Invasive



These lizards are carnivorous. They eat chicks and eggs from bird nests and dig for sea turtle eggs in the sand.

GEECH Native
Rats and mice Invasive



Rats and mice negatively impact nesting seabirds on many remote islands.

MAAW Native
Parrotfish Invasive



Parrotfish are very important to Ulithi culture and way of life. As they feed, they clean the reef and keep it healthy. Parrotfish are quite large, peaceful, and are easy to catch. For these reasons they are protected and managed on Ulithi.

Ulithians have three different names for various sizes of parrotfish. Small parrotfish are called "Thilmow," medium sized are "Mau" and large parrotfish are called "Hafuul". Parrotfish meat is very soft. It is traditionally brought to mothers daily to eat after a new baby is born.

HANGAAW

Brown Noddy

 Native
 Invasive

Credit: J.J. Harrison



Brown Noddy nesting pairs remain companions for life. They nest in trees and on cliff sides.

GEREELFOEY

Brown Bobo

 Native
 Invasive

Credit: Emma Yealil



In Ulithian, Gear means weak and Foy means vulnerable. During nesting season, these birds are vulnerable and defenseless.

GIIGIY

Least Tern

 Native
 Invasive

Credit: Dan Pancamo



The least tern nests on the ground in sand and rocks. This nesting habit makes the tern extremely vulnerable to rats and monitor lizards.

FASUW

Giant Clam

 Native
 Invasive

These clams can weigh more than 440 pounds (200 kilograms), and can live over 100 years.



Threats to the Reef: Causes and Effects

As you read, underline the causes and effects of the damaged reef ecosystem of the Ulithi Atoll. Glue the correct cards on the appropriate pages.



Monitor Lizards



Rat Infestations



Overfishing

Cut on dotted lines



Global Warming:
Superstorms



Global Warming:
Rise in Temperature



Single Use Plastics

Causes ↑

↓ **Effects**



Algae growth



Coral Bleaching



Ruined turtle nests



Ruined bird nests



Marine Trash



Broken Corals



???

Cause

???

Cause

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Cause

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Effect

Explore the setting of the story

The story, "Palu, Man of the Sea" is set on the Ulithi Atoll, an outer island of Micronesia in the western Pacific Ocean. Ulithi is made up of 40 small islands totaling a land area of 1.75 square miles (4.5 square kilometers). The ring of islands spans an area 22 miles (36 kilometers) long and 15 miles (24 kilometers) wide. It has shallow reefs with breaking waves, colorful corals, schools of tropical fish and animals like octopus and giant clams. With such little land and so much reef, you can imagine how important the ocean is to the people who call it home. They depend on the reef for survival and caring for it is a traditional lifestyle.



What interesting things do you see at Ulithi? How would it be to live there?

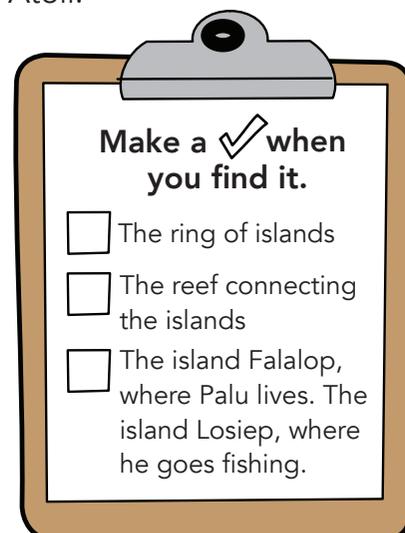
Explore Google Earth to see the Ulithi Atoll.



What you'll do:

1. Open your Internet browser and go to:
<https://earth.google.com>
2. Search "Ulithi Atoll."

3. Explore Google Earth to find the following features:



PALU, MAN OF THE SEA

Part 1: Palu the Navigator

One starlit evening on the Ulithi Atoll, a cool breeze blew through the coconut trees gently rustling their fronds. If you closed your eyes and sat underneath a thatched roof, you might think it was the sound of rain rather than the dry rustle of leaves. Tonight there was no rain. Mailap sat on the beach with her face toward the stars and listened to her Grandfather tell stories of their island's past and present.

"Mailap, do you know what great responsibility your name entrusts upon you?"

"I am named after the eastern guiding star to remind us to look toward the East," Mailap answered.

"Yes," Grandfather agreed. "East, toward the sunrise. Each sunrise brings us a new day and every new day should be better than the last. You, Mailap, must look toward the future and make today better than yesterday for our community and our lifeline, the reef. Many things about our island and reef are becoming different now," Grandfather continued.

"Different? How?" Mailap asked.



Photo credit: Wayne Sentman



Photo credit: Scott Davis

“Ah, I must tell you the story of Palu, Man of the Sea,” Grandfather answered.

A smile slipped across Mailap’s face—she loved storytelling. She buried her feet deeper into the soft sand and listened. And so, the story began;

Our story begins with a boy named Palu. The name Palu means “man of the sea,” or “ocean voyager”. Palu was strong and smart. He was an exceptional swimmer. He loved to jump from canoes and splash into the water.



Photo credit: Scott Davis

He was liked by everyone because he was willing to climb trees to fetch coconuts for them, but he also had a rebellious side. He didn’t always follow the rules.



Photo credit: Scott Davis

Part 2: Cultural Traditions

“As you know, Mailap, Ulithi’s culture has many traditions and rules to follow.” Grandfather commented. “These rules help us respect one another.”



“They also help us respect marine animals and our precious reef.”

“Like the rule, ‘don’t ever kill an octopus?’” asked Mailap.

“Yes, that’s right. Our ancestors didn’t kill the octopus because they believed it was sacred. They believed that certain families descended from the clever octopus.”

Grandfather continued with the story:

Palu was taught the traditions of his ancestors. From the time that he was very young, he was taught to collect and save a serving of the best parts of a meal and put them in a basket woven from palm fronds.

It was always Palu’s job to place the food basket in the ocean as an offering to Yalulwei, the spirit of ocean voyaging. Many hundreds of years ago, maybe even thousands, Yalulwei traveled throughout all the regions of Micronesia teaching the people his expert knowledge of traditional ocean navigation. It is said that he began to learn the art of ocean navigation while



A dugout canoe at The Outer Islands.

Photo credit: Scott Davis

still in the womb.

The people of Ulithi have always sought to find favor in the sight of Yalulwei for protection during long canoe journeys to neighboring islands.

The act of giving up a little of that which you like teaches us to be unselfish. This way, we can learn to live without excess riches or food. We take only what we can use and we use only what we need.

As Palu got older, he stopped making offerings—instead, he ate his fill and gathered all of his trash and cast it into the sea. He cast the bones, coconut shells,



cooking leaves and waste into the water.

He called out, “Here you go Yalulwei, eat your fill!” Then he would laugh and walk back to the hut.

Palu’s little sister, Yaad, however, saved a few bites of her favorite food carefully wrapped in a taro leaf. She then set her insignificant offering in the sand where the waves gently lapped at it and drug it back into the water. Yaad patiently watched her offering until it disappeared into the sea.



An octopus at the Ulithi Atoll.

Part 3: Giit, the Naughty Octopus

Suddenly, Yaad saw a ripple on the surface of the water!

“Giit! I see you at last,” she whispered. “You boneless creature!”

Although no one else on the island had actually seen Giit before, Yaad couldn’t seem to get rid of him. No one believed her stories. Palu believed Giit, the octopus spirit, was just a myth and made fun of Yaad. He told her that the mythical spirit

was just her imaginary friend. But, Giit was back, and he was trying to steal Yaad’s offering—again!

“Oh no you don’t!” Yaad exclaimed as she jumped into the shallow water to intervene. All of a sudden there was a splash and a great cloud of black ink in the water. Yaad recovered the taro leaf offering and triumphantly held it high in the air.

“That’s the last time you steal from me!” she said as she threw the offering as far into the sea as she could where she was sure Yalulwei would get to it first.

Then, she picked up a coconut shell bowl from the trash pile. It was cut shallow with smoothed edges and still had a thick husk on the outside. She threw it into the water after Giit.

“Take this old coconut shell and use it as a canoe to go far away from here!” Yaad

A family relaxes at their home on The Outer Islands.

Photo credit: Scott Davis





Photo credit: Scott Davis

Boys play in a traditional canoe at the Ulithi Atoll.

called out to the beast!”

She ran inside to tell her family about Giit, because this time she had proof—Giit’s ink was still visible in the water!

Of course, no one cared to walk outside to look. Instead, Palu just laughed at her.

He was busy preparing for his fishing trip. He gathered his luckiest fishing gear. He was going to leave at first light.

“Palu, take me with you tomorrow in your canoe,” Yaad begged. “I want to see the fish too.”

“We have serious fishing to do.” Palu scoffed. “You must stay here and play with your imaginary friends!”

Yaad scowled and walked away. She was not ready to take no for answer from her bad brother. When everyone was fast asleep she sneaked out to Palu’s canoe

and hid underneath a palm mat. She quickly fell asleep in her hiding place.

At first light, Palu left the hut quietly, careful not to wake Yaad. He climbed into the canoe stepping on the palm floor mat where Yaad lay sleeping. Abruptly awoken, she squealed in pain.

“Yaad! What are you doing here? You must get out at once! You cannot be tricky and disobedient like this!

“I’m not the disobedient one,” she cried. “You are the rebellious one! You should be afraid of Yalulwei! You give him all of your trash and you take every fish out of its season! The sea will surely swallow you up!” she cried as she turned and ran away.

“I don’t believe in fairy tales and superstitious fishing rules! exclaimed Palu. “Those are the way of the past!” he continued. Then, he cast off into the water.

Part 4: Ancient Fishing Rules

Our ancestors alternated fishing areas regularly. In our atoll's history, some areas of reef were reserved for fishing only during festivals and celebrations. Other areas would be closed for a time to respect the passing of an elder or leader. Whatever the reason for a restriction, these closures gave fish populations time to recover after fishing activities. Because of these restrictions, in the past, most places on the reef

were not fished two years in a row.

But, waiting to fish required patience, and patience, for Palu, was in short supply. He was mostly concerned with catching the biggest, most colorful fish whenever and wherever he wanted.

Over the years, Palu had been saddened as he watched his reef grow less colorful. The reef was becoming overgrown with algae. The fish had become smaller. Now, they were much harder to find and even harder to catch.



Cause



Effect

How does overfishing affect the reef?



Before: Healthy Ulithi reef



After: Bleached reef with algae growth



Lately, Palu had noticed white patches of bleached and deadened corals where vibrant blue and orange corals had once been. Additionally, typhoons were hitting the island more frequently and the storms were much stronger than in times past.

Scientists visiting the island said that the unusual superstorms were caused by climate change as a result of global warming. White coral skeletons fanned across the seafloor in some areas and in

other areas where the coral was broken up, it was already black and dead.

The reef was unhealthy. It was dying! Now that fish were not plentiful, Palu had a long journey ahead of him to find a place to fish. He would not be home till dark.

Yaad sat under the shade of a tree with a cross look on her face and her arms folded.

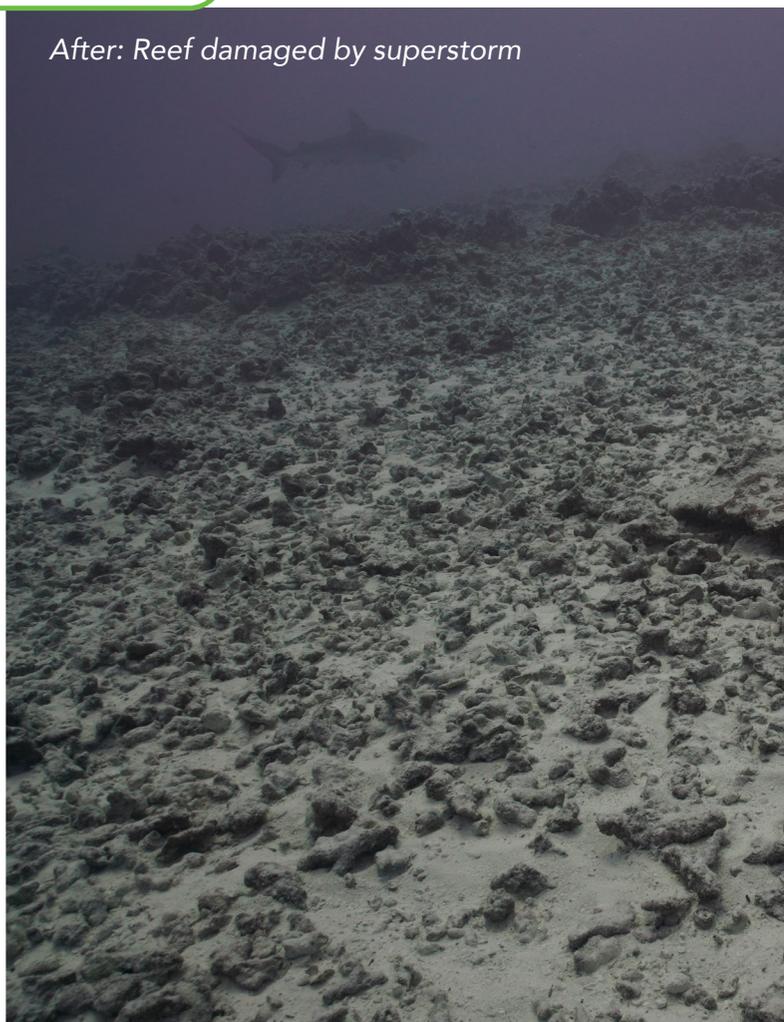
How do typhoons and superstorms affect the reef?



Before: Healthy Ulithi reef



After: Reef damaged by superstorm





As Palu's canoe disappeared into the distance, her expression changed to concern. Yalulwei could make the sea swallow him up. Even Giit could cause trouble for her rebellious brother!

In a panic, Yaad rushed to find a way to follow Palu. She had no canoe and no paddle. She quietly grabbed her goggles and dashed to the other side of her island to find the great blue hole in their reef. Her father had told her that she was not allowed to approach, swim, or dive near the blue hole, for it was the home of Giit, the mischievous octopus spirit.

Giit loved to steal things such as fish, stones, and shells from the islanders. No one dared go near Giit's home to recover the objects that he had taken.

Yaad had no canoe, and Giit owed her an

apology! With determination, Yaad swam closer to the blue hole. She saw that the ground was covered with large sea shells, stones, and other trinkets. There were many giant clam shells, which the islanders prized. Her heart pounded in fear but she continued diving deeper until she reached the edge of Giit's lair. She grabbed onto a giant clamshell and freed it from the sand. The heavy shell floated to the surface as if magic lifted it for her. She quickly climbed inside it as if it were a canoe. She made a paddle from the wide base of a palm frond and set off to find her brother.

She paddled for what seemed like hours. She couldn't see land. She used the position of the Sun to paddle south and east toward Losiap, the neighboring island that Palu meant to visit.





Many small islands are connected by reefs on the 200 mile atoll.

Part 5: Broken Promises

It began to rain, and as sunlight shined through the drizzle it formed a beautiful rainbow that seemed to smile down at Yaad . After hours of paddling, she spotted Palu and called out!

“Palu! It’s me!”

Palu changed course and quickly came to pick her up. Yaad ’s clamshell bumped into Palu’s wooden canoe and she gripped onto it tightly.

Palu was very angry and immediately began scolding Yaad for her foolishness. He pulled her into his canoe. Suddenly, Giit’s giant tentacle broke through the surface of the water and gripped tightly to the magic clamshell and pulled it down taking back his prized possession.

“That pesky octopus! cried Yaad.

Palu was speechless and stopped scolding his younger sister. He just stared at the surface of the water where the giant clamshell had disappeared moments before.

The smiling rainbow quickly turned into a gray frown and the sea got rough. Great winds began to blow. Large waves quickly capsized the little canoe and Palu and Yaad swam for their lives holding onto a bundle of coconuts for flotation.

All of their other possessions were lost to the storm, including their canoe. In the dark of the night they were floating in the ocean. When they thought they would surely never make it back to shore, Yaad ’s feet bumped into something hard.



It was coral! They were saved!

They found their way onto a tiny island, collapsed onto the sand and did not wake up till morning. When they woke, they found themselves hungry, thirsty and stranded.

Palu spotted markings in the sand—the site of a sea turtle’s nest. Every five years, the majestic sea turtles came to shore to lay their eggs. They could lay clutches of up to 100 eggs, which they covered in the

sand—a promise buried and hidden for safekeeping.

When Palu dug into the sand all he found were broken egg shells. The nest had been decimated by monitor lizards—the promise buried could not be kept.

The lizards had been accidentally introduced to the islands a very long time ago—longer than anyone could remember.

How are sea turtles affected by invasive species?



Cause



Effect

A sea turtle lays its eggs in a hole in the beach sand.



Rats dig up the eggs and eat them before they hatch.



Turtles are becoming more and more scarce every year because the monitor lizards eat the sea turtle eggs.

From this nest, we will never see a parade of baby sea turtles marching to the sea.

Palu and Yaad continued searching the small island for food or water. Palu had been to the island in the past to collect seabirds and eggs. Roast bird and cooked eggs was a delicious treat!



Palu was sure he would be able to catch a seabird on the opposite side of the island because it was nesting season.

When they got to the nesting area, all they found was one lone chick among many deserted nests.



In years past, the nesting area had been home to hundreds of loud squawking sea birds, but the bird populations had been damaged by rats which stole eggs right out of the nests.



Monitor lizards also lumbered around the beaches, smelling the air with their thick black tongues and quickly swallowed up any eggs or chicks they found.



Years ago, people had brought the fearless monitor lizards to the island in hopes that they would eat the rats.

Instead of eating the rats, the monitor lizards found easier meals in the ground nests of the elegant least terns. Rats still had the habit of invading the nests of the brown bobo and the magnificent brown noddy.

Because these seabirds had existed for thousands, or millions of years on the islands without predators, their nesting behaviors made them vulnerable to the

newly introduced predators. A seabird egg laid on the ground is just sitting there for the taking.

In addition to monitor lizards, what other newly introduced animal ruins seabird nesting areas?



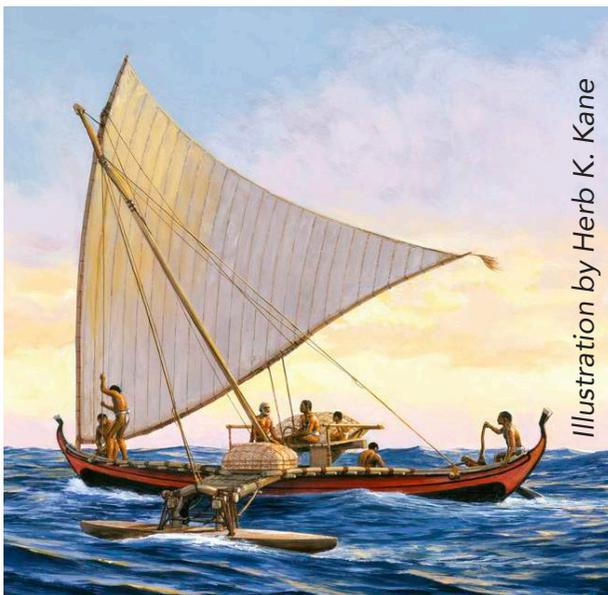


Part 6: The Offering

Yaad spotted an outrigger canoe pulled up on the shore.

"I thought this island was uninhabited," Yaad said with surprise.

On the side of the canoe was a voyaging hut neatly woven from coconut palm fronds. Together, they cautiously approached the hut and peered through its opening.



Inside the hut, they saw a perfectly woven palm basket with a small taro leaf bundle tied neatly with grasses. It looked just like Yaad's tiny offering.

A clam shell full of water was set next to the offering. It wasn't enough water to drink, rather, it was only enough to wet your mouth.

"That's my offering! This must be Yalulwei's hut!" Yaad gasped.

"What?" Palu said as he looked around cautiously. No one was in sight.

Palu looked at the clam shell and the food.

"Oh what I'd give for a bite of food right now! There's one bite for me and one bite for you!" Palu exclaimed as he reached out his hand to grasp the tiny offering.



Suddenly, they heard a booming voice call out, "You enter my hut without a word? You reach out to take my food without permission?"

Palu stammered and fell flat on the floor with fear. "Yalulwei? He said in complete disbelief."

"Palu, I see you are tired and hungry. Go now, leave my hut—for your feast awaits you at the water's edge," Yalulwei scoffed.

Palu rushed out of the hut, tripping on his way out. He ran down to the water's edge where all he found was a great pile of trash. Fish fins and bones were strewn across the sand. Tea leaves used for cooking floated in the water. The tough leaves were not edible. He recognized the mess as his own trash.

Palu desperately sorted through the trash hoping to find something to eat. His salty mouth became more dry and his hungry stomach began to churn.

“Have you eaten your fill, Palu?” Yalulwei called out from the hut.

Palu was embarrassed. Words couldn’t express his regret. He just stood there in the water surrounded by his litter.

Yalulwei continued, “The gods gave you these islands and I taught your people to

voyage. I taught your ancestors how to use the sea to sustain your people. You feast from the sea, and all you gave back to the sea in return was your trash.

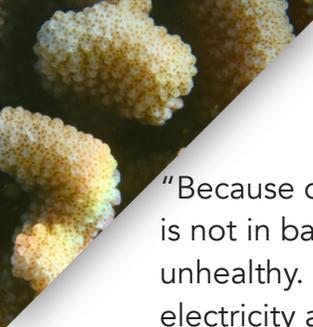
You fish in and out of season. You do not rotate your fishing areas. You take more than you can use. Animals eat your litter and it makes them sick!”

Palu was so ashamed he remained speechless with his eyes cast down.

How does trash in the water effect the reef ecosystem?







"Because of your carelessness, my sea is not in balance and my corals are unhealthy. People burn diesel fuel for electricity and pollute the air with their exhaust. Exhaust and pollution are causing climates and the ocean to warm. My reef is dying!"

Palu was sad and ashamed.

"After all that I gave you, now you are hungry." Yalulwei said.

Holding up the taro bundle in his hand, Yalulwei continued, "The taro offering that Yaad kindly gave to me is not enough to fill my belly. I am hungry too!"

Yalulwei approached Yaad and handed the offering back to her along with the tiny clam shell containing the water.

"Thank you!" she replied with the greatest respect.

Yaad carefully unwrapped the bundle and divided its contents—one bite for her and one for Palu.

They savored the taste of the single bite of taro and meat. To Yaad's surprise, when they had finished their tiny meal, two more pieces of taro and a scrap of juicy meat still remained on the taro leaf.

One bite at a time, they ate more and more delicious food from the tiny offering. They drank a never ending supply of water from the tiny clam shell. When they felt like they were about to burst, Yaad respectfully wrapped the taro leaf around her tiny offering. She tied it shut and returned it to Yalulwei.

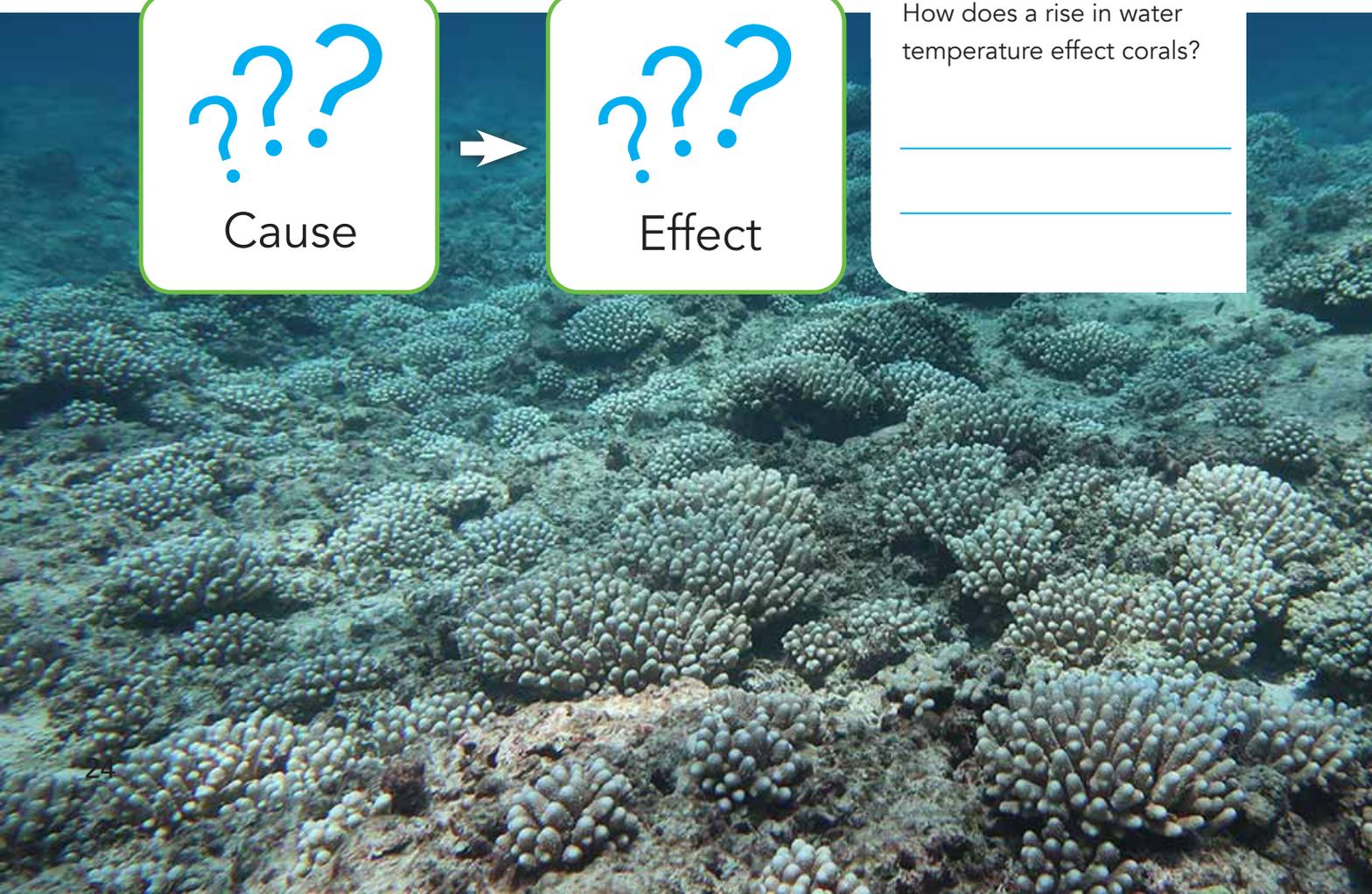


Cause



Effect

How does a rise in water temperature effect corals?





Part 7: A Glimmer of Hope

Palu vowed to care for the reef and to fish according to the traditions and rules set forth by his ancestors.

Yalulwei held up a tiny black stone that glimmered in the sunlight. "Although this stone is dark, all light is not lost from it," Yalulwei stated. "Although my reef is dying, all hope is not lost for it either. If you keep your promise and change your ways, the health of the reef will be restored. If you break your promises, the future of this reef will be dark like this stone."

Yaad eyed the beautiful stone. Yalulwei handed it to her. At that very moment

Yaad was drenched by a great splash. She felt the slimy surface of a strong octopus tentacle on her hand and the black stone slipped from her fingers."

"Giit!" she exclaimed. "That rascal!"

Sputtering, she rubbed saltwater from her eyes and in front of her, resting in the sand, she saw a giant coconut shell bowl. Amazingly, it was as large as the giant clam shell. Yaad immediately recognized it as Giit's coconut shell canoe! It was cut shallow with smoothed edges and still had a thick husk on the outside. She climbed into the magic coconut shell with her brother and floated home to their tiny island—their beloved island home.



Part 8: A New Day

Palu shared his experience with all the other islanders. His story was told all over the atoll and neighboring islands. The islanders began to use their ancient traditions to regulate their fishing activities, and slowly, the health of the reef began to return.

Palu never bothered his sister again about having imaginary friends. Now, with Palu's help, Yaad continues to prepare generous offerings for Yalulwei. Yaad always includes a shiny stone for Giit, too. She sets the stone in a coconut shell and watches carefully as it floats out to sea.

And, so, Palu's story ended, but yours is still beginning," concluded Grandfather. When he looked down at Mailap, he saw that his precious granddaughter had fallen asleep. He pulled a blanket over her.

At daybreak, Mailap awoke to view the Sun rise over the Ulithi Atoll. It was a gray-blue morning ripe with streaks of pink and orange possibility. A cool breeze whispered through conch shells. If you closed your eyes, you might think it was the sound of a healthy, vibrant ocean.

Mailap had listened to her grandfather's words. She wanted to make a difference! That morning, Mailap looked to the East toward a new day.

Community members gather in a hut to plan how they will take action to save their reef.



Photo credit: Scott Davis

Research and Explain: Humans Affect Reef Ecosystems

Use the information from this journal article and other reliable media sources such as books, web pages and videos to answer the following questions.

What human activities can have negative effects on reef and coastal ecosystems?

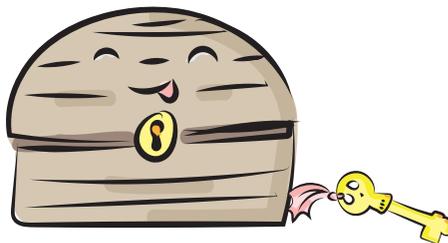
What effects do these activities have on the reefs and the animals that live in them?



Riddle

It starts with curiosity
And ends with understanding
To find answers to your questions
Requires careful planning
This helps you think methodically
To be the author of discovery
All scientists use it and you can use it too

What is it?





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Protecting Reefs with the Scientific Method
Palu, Man of the Sea

Teacher Edition

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