AMP IT UP

Advanced Manufacturing & Prototyping Integrated to Unlock Potential

7TH GRADE SCIENCE

Decision Making

DON'T WRECK THE REEF

Coral Reef Challenge

Annotated Teacher's Edition

7DMS

SECTION 1 – THE CORAL REEF CHALLENGE

1.1 INTRODUCTION

The focus of Section 1 is to provide students with a background of the Reef Challenge. Students are introduced to the Republic of Fiji and environmental factors that affect the economic growth of the island. Specifically, students will learn about changes in the coral reef along the coastline of Fiji. They will look at pictures of these degraded reefs (or reefs that are bleached and have been overrun with seaweed) and understand how this degradation can affect the quality of life in Fiji.

In many areas of the world, communities rely heavily upon their surrounding resources to support their lives. Countries harvest these resources to sell and support their national and local economies. Additionally, some countries rely on the natural environment to provide for day-to-day needs, like food or shelter, for its citizens. An example country is the Republic of Fiji (*FEE-gee*). Fiji is located in the southeast Pacific Ocean, near Australia.

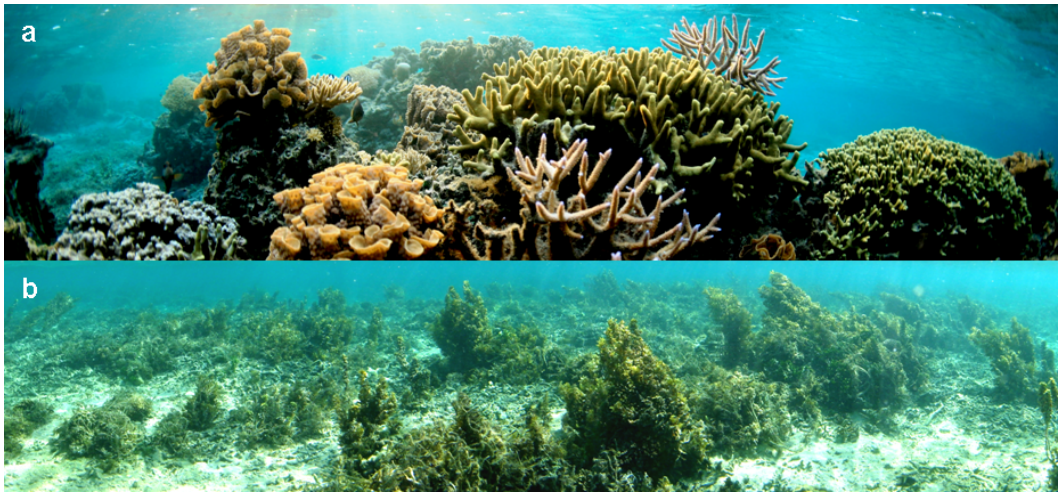
The Republic of Fiji is actually a collection of 332 islands formed by volcanic activity beginning some 150 million years ago. It is one of the most developed economies in the Pacific due to a wealth of timber, mineral, and fish resources. In recent decades, tourism has also become an important part of the economy.

The islands are surrounded by coral reefs. The coral reefs are home to a wide variety of marine wildlife.

The coral reefs are fished for a number of species. This fishing supports many local economies all over Fiji. It also provides local communities with a good source of food.

1.2 PROBLEMS AT THE CORAL REEF

Recently, Fiji has witnessed changes in some portions of the reef located around a small town on the southwest coast of the nation. Once healthy and vibrant reefs with abundant wildlife have become bleached and overgrown with seaweed. These reefs are known as **degraded reefs**. Picture A shows coral that is vibrant and healthy. Picture B is taken at the exact same location ten months later. Picture B shows the coral has degraded and seaweed has overrun the surface. This condition also seems to be expanding to more and more areas around Fiji.



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Watch the video of the pictured coral reef that degraded in only 10 months.

Play video 1 which introduces students to the research of the GT team & Dr. Hay

Watch ***Degraded Coral Reef*** video.

The citizens are concerned about this degradation because the reef is important to the quality of life in Fiji. It supports fishing, tourism, local traditions, and culture. Fiji's government has turned to a team of Georgia Tech scientific researchers for help. Georgia Tech Biology Professor, Dr. Mark Hay, heads the team that has expertise in studying degrading coral reefs.

Dr. Mark Hay
Biology Professor
Georgia Tech

Reef Research Team

DOUG DANIELLE PAIGE JULIA ROBERTA

Watch the video of Dr. Hay describing the healthy and degraded zones in Fiji.

Play Video 2 of Dr. Hay & the research team- students should be able to describe the difference between a healthy and degraded coral reef zone

Watch ***Dr. Mark Hay*** video.

The coral reef research team has a lot of experience in diagnosing reef problems. They know that the health of a reef depends heavily upon how the organisms living near the reef interact. The researchers goal is to learn more about how organisms on this particular reef interact. Working on this goal will help Fiji better understand the problem they are facing and what they might be able to do about it. Your challenge is to assist Dr. Hay's team with analyzing reef data and then to provide the citizens with recommendations on how to manage their coral reefs.

KEY TERMS

Ecosystem: a community of organisms that interact and are all influenced by all other aspects of the environment

Biotic Factors: living organisms in an ecosystem

Abiotic Factors: non-living (physical or chemical) components of an ecosystem

Habitat: natural home or environment of an animal, plant, or other organism

Herbivores: plant-eating animals

Carnivores: animals that eat other animals

Food web: diagram that shows connections between all the plants and animals in the ecosystem

Food chain: diagram that shows direct relationship of what organisms eat each other

Reiterate to students that they will be assisting GT Biology Professor, Dr. Hay & his research team to diagnose problems in the coral reef & to examine how organisms on the reef are interacting. Ask students what their challenge is- it's to assist the Georgia Tech team to analyze reef data & provide the Fiji citizens with a better sense of what might be wrong with the reef.

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SECTION 2 – ADD TO YOU UNDERSTANDING

2.1 THE CORAL REEF ECOSYSTEM

This section includes the background information on the ecology of the reef. It includes key vocabulary and concepts thaty they will use to solve the challenge and focuses on the specific food web that exists within the reef. You may wish to have students copy these definitions as part of their notes.

To better understand this problem, we need to understand the role coral reefs play in Fiji's ecosystem. We also need to understand how the reefs are used as habitats.

An **ecosystem** is a community of: 1) living organisms (plants, animals and microbes, also known as **biotic**), and 2) nonliving parts of an environment (things like air, water and soil, also known as **abiotic**), that interact and are influenced by all other aspects of the environment. A **habitat** is the natural home or environment of an animal, plant, or other organism. In a habitat, the organisms are dependent upon each other for survival. Some plants serve as food for other animals. Plant-eating animals are known as **herbivores**. In turn, some of those plant-eating animals can be the food for other animals. Animals that eat other animals are called **carnivores**.

Discuss additional food web examples & have students identify the predator/prey in each:
http://examples.yourdictionary.com/examples-of-food-chains.html offers more examples

The connections between all the plants and animals in the ecosystem form a **food web**. For example, a food web in a meadow or prairie would include grassy plants, foxes, hawks, rabbits, and ants. A **food chain** would show a direct relationship of what organisms eat each other. In this example a food chain would include grassy plants, rabbits, and foxes. The grass grows, and the rabbits feed on the grass. These rabbits, in turn, serve as food for the foxes. In a food chain, we label certain organisms as the eaters and some as the eaten. So, food chains have two types of organisms: **predators** and **prey**.

KEY TERMS

Predator: an organism that feeds on another organism

Prey: an organism that is attacked and eaten by another organism

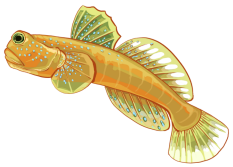
Discuss these questions as a class:

1. What are some other examples of food chains that you can name?
2. Can you identify the predator and the prey in your examples?

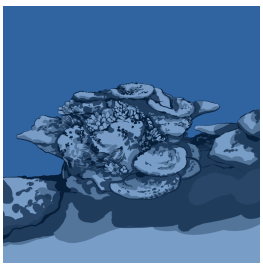
At the coral reefs around Fiji, one food chain involves four organisms:

Fishing Crews

Goby Fish



Seaweed



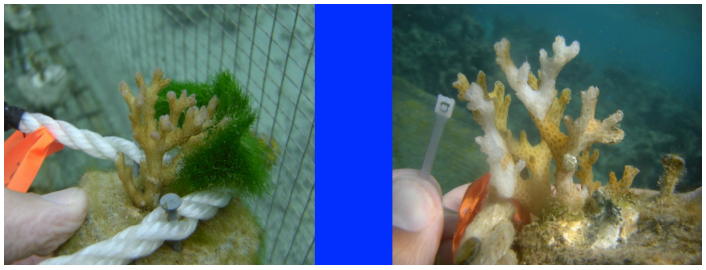
Coral

Review the coral reef predator-prey relationships with students- you might prefer to illustrate the relationship on the board. The predator-prey relationship between the seaweed & coral might be confusing to students if they expect that the predator always eats prey.

This food chain has two predator–prey relationships:

1. The fishing crews are predators of the Goby fish (prey).
2. The Goby fish are predators of the seaweed (prey) because they eat the seaweed.

What about the relationship between the seaweed and the coral? The seaweed actually produces a chemical as it grows on the coral. This chemical is harmful to the coral near it, making it a predator of the coral. Notice how the seaweed has bleached the coral where it was growing next to it.



Before

After

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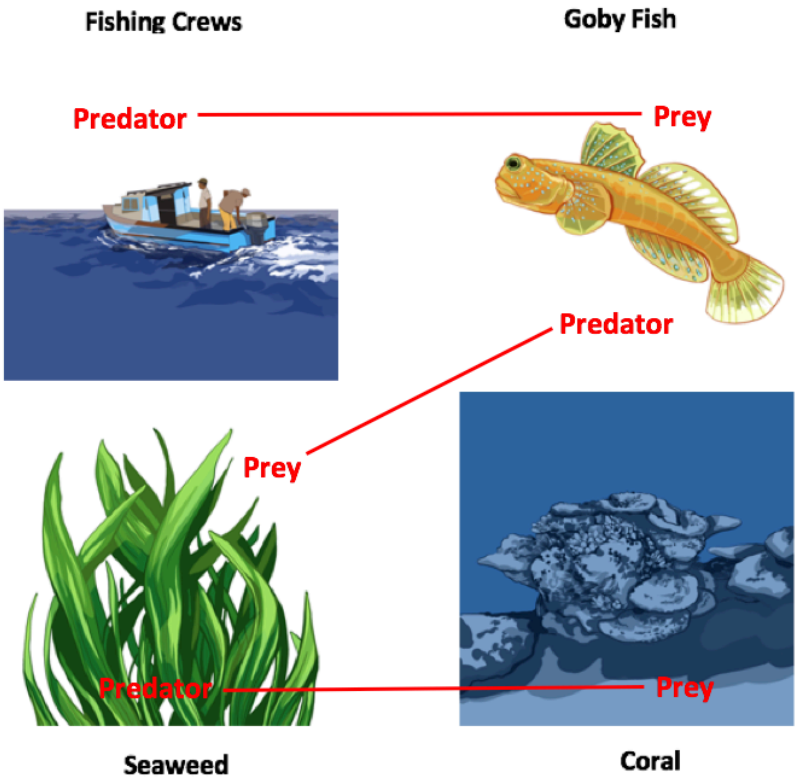
Due to this interaction, this food chain has three predator-prey relationships.

a) The fishing crews (predators) catch the Goby fish (prey).

b) The Goby fish (predators) eat the seaweed (prey).

c) The seaweed (predator) kills the coral (prey).



The Reef Research Team knows that the health of the reef can be affected by the number of each of the organisms within a certain area of reef. If too much seaweed grows, the coral will die so there must be enough Goby around to eat the seaweed. Of course, too many fishing crews will affect the number of Goby. The right balance of each organism in the food chain is critical in making sure all of the organisms thrive and sustain their population.

Review the importance of maintaining the right balance of organisms- just reading these relationships won't be enough for students to understand the interdependence

Discuss this question as a class:

Based on what you've learned about ecosystems and food chains, what are some possible reasons why the coral reefs are degrading?

SECTION 3 – INVESTIGATE THE FOOD CHAIN

3.1 SURVEYING THE CORAL REEF

In this section students learn more about the sections of the reef that will be investigated and conduct simulations to learn more about the health of different sections of the reef.

In order to understand the balance of the food chain, the Reef Research Team will survey and count each of the four organisms on the reef in a predetermined area. Your class will simulate this same exercise in your classroom with data that the Reef Research Team collected. Because you cannot go to the actual reef, you are going to use a model, or **simulation**, of the reef to survey. You will use a variety of colored counters to act in place of the fishing crews, Goby, seaweed, and coral. Armed with this data, your class will decide how best to inform Fiji of what is happening.

After a long flight across the Pacific Ocean, the Reef Research Team arrives in Fiji with their equipment. They travel to the affected area near the town of Vatukarasa in the southwest of Fiji. There, they meet a local official and guide.

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As the group travels along the coast, the team learns some important information from Fiji's government officials:

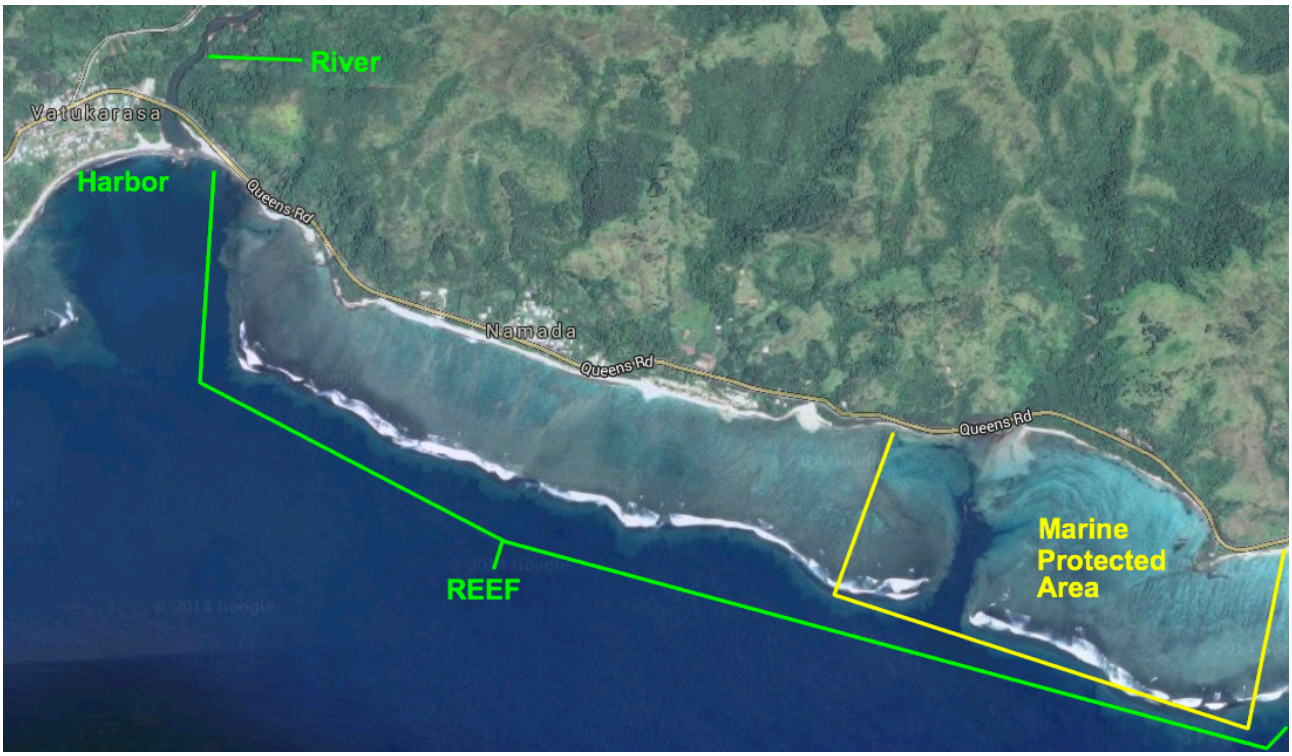
1. They learn about the area, the people, and culture. This includes an explanation of how important the fishing industry is to this community.

2. They review a satellite image map of the coast near Vatukarasa. Just off the coast, under the water, you can see the large coral reef. The Reef Research Team decides they will need to identify smaller sampling locations to complete the survey.

3. On the east side of the area, there is a Marine Protected Area (MPA). Fiji's government created the MPA many years ago to protect one of Fiji's most beautiful beaches. A resort developer wanted to build a resort and hotel on the beach. It was a large political fight, with many tourism supporters arguing for the resort. In the end, the people of Fiji voted to protect the beach and coastline from development forever.

4. The fishing crews in the area receive their annual fishing permit from the town of Vatukarasa. They can fish anywhere along the reef, but they must launch their boats from the harbor. Only a small handful of crews are allowed to fish in the Marine Protected Area (MPA), and those crews pay twice the fee for their permit.

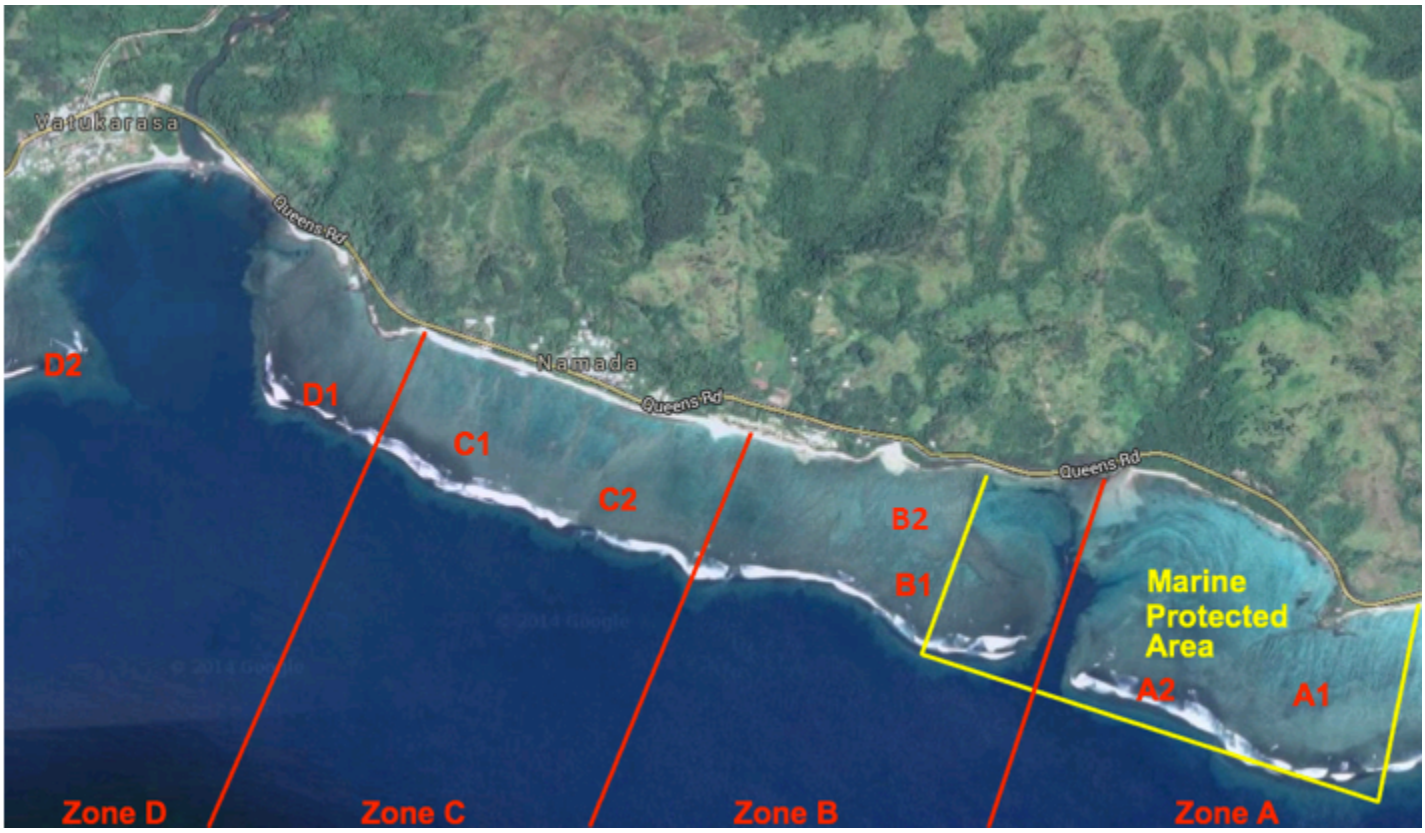
Review #3 & #4 closely- it is important that students see the competing interests for taking care of the reef and why the MPA exists and why the fishing crews would have to pay more money for their permits. The notion that there are competing interests between environmental protection & economics is an underlying theme in this section



After the tour, the Reef Research Team is ready to start their work. They decide to divide the reef into four zones: A, B, C, and D. The team divides into pairs, and prepares for a scuba dive exploration in their zone. For each of their sampling locations, the team will count the number of:

- Fishing Crews,
- Goby,
- Seaweed Plants, and
- Living Coral.

The Reef Research Team will then use this data to project the future health of the reef zone. Using your model, you and a partner will similarly investigate one of the sampling locations to better understand the health of the reef.



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3.2 GOBY FOOD WEB INVESTIGATION: CURRENT POPULATION

First, your group will explore an untouched ecosystem of Goby and coral. You will receive a canister of colored chips representing the organisms in your assigned zone. You will notice that four different color counters are in the canister. Each one represents the following:

- 1 **Orange** Counter = 1 Fishing Crew
- 1 **Purple** Counter = 100 Goby fish
- 1 **Pink** Counter = 10 feet of living, healthy Coral
- 1 **Green** Counter = 1 large clump of Seaweed

Follow the procedure to investigate the current population of organisms.

Procedure:

1. Collect the following materials:
    - (1) *Procedure #1 Current Populations Sheet*
    - (2) *Reef Survey Data Sheets* (one for each student)
    - (1) *Reef Survey Sorting Sheet*
    - Cardboard tray
    - Canister labeled with your assigned sampling zone
2. Read through *Procedure #1- Current Populations Sheet* to make sure you understand it.
3. Complete the Current Population procedure and record data on the *Reef Survey Data Sheet*.

Remind students to keep all the counters in the box and to sort the counters into the correct boxes. As students fill out the Reef Survey Data Sheet, they need to record this data in the CURRENT POPULATION row. Remind students that the counters to organism relationship is not a 1:1 relationship in all cases and they will have to multiply accordingly. **Have the answer key to each zone handy so that you can oversee how the students are working on this.**

Really stress to students the importance of working through these simulations slowly and carefully. They really need to be focused on these steps and not getting distracted by other groups. Each new part will have its own procedure.

3.3 GOBY FOOD WEB INVESTIGATION: YEAR 1 SIMULATION

The Reef Research Team has studied this particular food web at thousands of reefs. As a result, they are able to project how the organisms will affect each other. They then can predict what will happen to the number of each organism in the sampling location over the course of the next year.

Recall the predator-prey relationships in the reef ecosystem:

- The fishing crews (predators) catch the Goby fish (prey).
- The Goby fish (predators) eat the seaweed (prey).
- The seaweed (predator) kills the coral (prey)

Follow the directions on *Procedure #2- Year 1 Simulation Sheet* to simulate the effect of the predator-prey relationships in your sampling zone for Year 1.

Stress that part 1 was a survey of the current population and it is possible to now predict how those population totals will change based on the research that Dr. Hay's team has done. Remind students to write down their sampling zone. The Year 1 Projected Population is the first row of the second chart on the reef survey data sheet. The overall health column will be left blank for now. You might want to guide the students as a class through this.

3.4 GOBY FOOD WEB INVESTIGATION: YEARS 2-5 SIMULATION

You will now conduct four (4) more rounds of your simulation to predict what will happen in additional years. Since organisms reproduce and migrate from other areas, you will add some Goby, Seaweed, and Coral counters back to your squares between each "year" (run) of the simulation. During each round you will record the new data in your *Reed Survey Data Sheet*, and color code the overall health of the sampling zone as being either **good** or **poor**.

Follow the directions on *Procedure #3- Years 2-5 Simulation Sheet* to simulate the predator-prey effect on your sampling location's organisms for Years 2-5.

Again it is really important that students carefully follow the steps in this section to get accurate predictions of how the populations will change over years 2-5. Students might not realize if there are no seaweed left (for example), then they won't remove any coral because the coral can't be damaged if there are no seaweed present. They will also need to add organisms from the discard canister at the beginning of each round to represent organisms reproducing from one year to the next.

NOTE: teachers you will need the extra bags of coral and seaweed on your desk. Look at the answer keys. There will be situations where the coral and seaweed will grow unchecked and students won't have enough chips in their canisters to add at the beginning of each year. It is imperative at the end that students return the extra chips to you and leave in their canisters exactly what they started with.

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3.5 DATA ANALYSIS

In this section students will continue to work with the projected populations chart. They will shade in the population boxes either green or red based on the population chart for each organism. Finally they will fill out the overall health box for the environment (very healthy, healthy, unhealthy, very unhealthy) based on how many green/red boxes were colored in that row.

Part A

The Reef Research Team is able to use the projected populations to judge whether or not a reef sampling location is healthy and is likely to avoid degrading if:

- If the Goby and Coral numbers are higher than a certain number, that's good news. If each are lower than that number, it could mean trouble for the health of the coral reef.
- If the Seaweed numbers are low, that's good for the reef. If the number is high, the reef will likely suffer in the future.

Using data from their previous experience, the Reef Research Team created the table below. It will help you analyze your data.

GOOD		POOR
1500 or Greater	**GOBY**	Fewer than 1500
300 feet or Greater	**CORAL**	Fewer than 300 feet
Fewer than 10 clumps	**SEAWEED**	10 clumps or Greater

Part B

You will now return to your Projected Population Data Table on your *Reef Survey Data Sheet*, and code your data using the rules above.

Procedure:

1. Use a **GREEN** colored pencil to color in populations that are **GOOD**.
2. Use a **RED** colored pencil to color in populations that are **POOR**.
3. Review your projected numbers for all organisms and use this key to decide the overall health of the reef. Write the level of health in your projected populations data table.

VERY HEALTHY	**All 3** organisms are **GOOD**
HEALTHY	**2 of 3** organisms are **GOOD**
UNHEALTHY	**2 of 3** organisms are **POOR**
VERY UNHEALTHY	**All 3** organisms are **POOR**

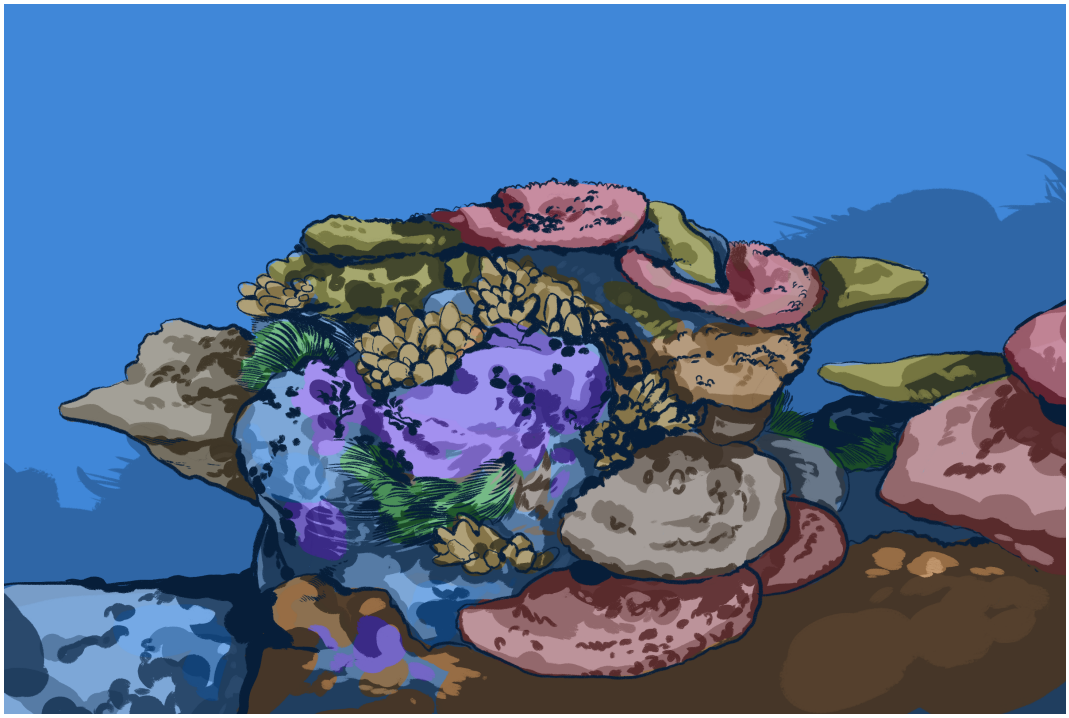
3.6 SHARE AND DISCUSS THE RESULTS

Your teacher will lead a class discussion of the results. Each group will report out their initial population data, their number of fishing crews, and the overall health of their sampling location at Years 1-5. The class will then discuss what conclusions can be drawn from the simulation.

During this discussion refer students back to the map of the reef & review the zones. Why is there such a difference in health between zone A (MPA) and Zone D (location of the harbor)

Discuss these questions as a class:

1. What does your analysis suggest about the health of Fiji's coral reefs?
2. What advice do you have for the Fiji government about how to keep the coral reefs healthy?



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SECTION 4 – MAKING DECISIONS BASED ON DATA

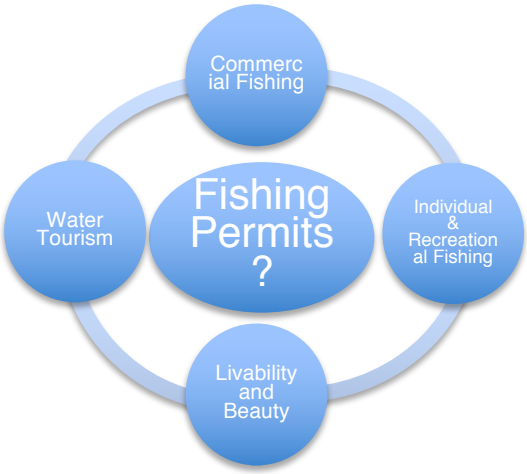
4.1 INTRODUCTION

Several trends were highlighted during your class discussion, including:

- When there are more fishing crews, the Goby population drops.
- The greater the number of clumps of seaweed, the more harm is done to coral.
- When there are few numbers of fishing crews and seaweed clumps, the Goby and coral do better.

This returns to the situation where there are competing interests with the reef (environmental protection and economic interests). Stress to the students that decisions about fishing in the different areas will be dependent on the local interests- you can't protect the entire reef from all fishing but at the same time it is important to preserve some areas for their natural beauty and tourism interests

How can this information be used to make decisions about the reef zones? As you have seen, the number of fishing crews will have an impact on the health of the coral reef. Suggesting that fishing should be eliminated might not be popular given how important fishing is to the local economy. Citizens fish to feed themselves. Commercial crews fish to earn money to support their families. The crews also support the local economy, for example by providing fish for the local restaurants. Local resorts attract tourists who like to fish for fun, and those tourists spend money at the hotels, restaurants, and gift shops. Alternatively, healthy coral is also important to Fiji's economy. Resorts attract scuba divers, swimmers, kayakers, and sailors who pay a lot of money to see healthy coral and a variety of fish, not seaweed and dead coral. Everyone agrees that a healthy environment makes for a more beautiful and livable place but fishing is important also. Your team will need to take these competing interests into account when deciding how many fishing crews to allow in different areas of Fiji.



4.2 WATER USE PERMITS

These categories of permits are extremely important for the activities in this section. Students need to understand what the permits allow and they will need to match up the correct permits with the needs of the region in the next activity.

The town councils in Fiji decide what types of activities will be allowed in the aquatic regions in their areas of the island. Three types of water use permits are available.

1. **Commercial Fishing Permits.** These permits allow commercial fishing boats to fish in the area with nets, and to take large numbers of fish to sell to restaurants. Most of the fish that commercial crews catch are big fish that people like to eat, and that are plentiful in the area. The use of large nets however always also catches Goby. Scuba divers, swimmers, kayakers, and sailboats are allowed in areas that allow commercial fishing.

2. **Individual Fishing Permits.** These permits allow people with fishing poles to fish for themselves. This method of fishing causes less damage to the Goby population than the commercial fishing. These permits are needed by people at the resorts who go out in small boats to catch sport fish, and also by local people who fish for food. Scuba divers, swimmers, kayakers, and sailboats are also allowed in areas that allow individual fishing.

3. **Recreational Water Use Permits.** Areas with these permits have restricted use, and do not allow any fishing or motorboats. Scuba divers, swimmers, kayakers, and sailboats are allowed.

4.3 DON'T WRECK THE REEF CHALLENGE

Your team will receive three new canisters and each canister will represent a location on the island. Each canister will contain colored counters that will give you the current information about the animal and plant populations from the reef at that location. As an advisor to the town council, you must recommend what type of water use permits should be allowed in the area. Your recommendation should be based on the economic needs of the area and the animal and plant populations from the reef. If you allow fishing permits, you will need to specify how many of each will be allowed. You will use a computer simulation to explore the effect your decision will have on the reef for 10 years.

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4.4 REGION PROFILES

Region E

Region E has a stable economy, with little growth or losses over the last ten years. The region boasts a tourism hotspot for scuba tours, kayak tours, and recreational fishing. A nearby university has been researching the reefs in the area and has begun a coral reef awareness campaign in town.

Region F

Region F has a declining economy and is looking for a change. Historically, many people in town have made a living working on commercial fishing boats. A resort hotel that promotes ecology based tourism (like scuba diving) however, would like to buy land here and employ many local people. Its location makes it vulnerable to hurricanes.

Region G

Region G has a booming economy. The region exports fish to many Pacific Islands, and features several fish restaurants. Many citizens in this region have college degrees and work in local office buildings.

How these regions are used will determine what types of permits are required. Through questioning see if students recognize that some regions rely on having a reef that needs to be healthy to support the economy (E); other regions (G) have an economy that doesn't rely on needing a healthy reef and some others (F) are in transition. They also need to pay attention to the differences between the commercial and individual permits.

Discuss this question as a class:

1. How does the reef support the needs of each region?

4.5 PREDICT THE IMPACT OF FISHING PERMITS

The matrix (excel file) will allow students to simulate how the populations will change in each reef region over a 10 year period. They will run a simulation for each of the 3 regions. Students need to consider the needs of the region when they are deciding if (and how many) permits are needed for that location. As they decide the number of permits, they need to remember the needs of the region. If the health of the coral is important then they need to avoid "red" boxes for coral. If the health of the coral isn't as important, then likewise it's not as important to have green boxes.

You will now simulate the health of different regions after you give out fishing permits. The description of each region (E, F, and G) is found on the previous page.

Procedure:

1. Collect the following materials:
   - (1) *Procedure #4 Fishing Permits Simulation Sheet*
   - (6) copies of the *Coral Reef Permit Impact Decision Matrix* (three for each student)
   - (1) *Reef Survey Sorting Sheet*
   - Cardboard tray
   - Canisters of regions E, F, G

2. Read through *Procedure #4- Fishing Permits Simulation Sheet* to make sure you understand it.
3. Open the digital version of the *Coral Reef Impact Decision Matrix*. Your teacher will show you how to use it.
4. Complete the Fishing Permits Simulation procedure and record data on the *Coral Reef Permit Impact Decision Matrix*.

4.6 MAKE YOUR RECOMMENDATIONS

Your job, as advisor to the town council, is to recommend the number of commercial and individual fishing permits that should be awarded in each region you have studied. On your *Permit Recommendation Sheet*, give your recommendation for each region, and support each recommendation with information that you have discovered using the reef simulations and with a consideration of the local community.

Procedure:

1. On the *Permit Recommendation Sheet*, recommend the number of commercial and individual fishing permits that should be awarded to each region. Provide evidence for each recommendation.

Georgia Tech

Center for Education Integrating Science, Mathematics & Computing

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