

GRADE 5 UNIT 1 OVERVIEW

The Wonderful World of Corals

Introduction

Coral reefs are essential building blocks in complex and fragile ecosystems. They provide shelter and food that organisms need to grow, reproduce and survive. In turn, all of the organisms in coral reef communities play a significant role in the function and welfare of their ecosystem.

In this unit, students examine coral reef communities, identify organisms that live within the reef ecosystem, and learn their Hawaiian names. Students learn about the roles of producers, consumers, and decomposers in the cycling of matter and flow of energy as they interact in marine food chains and webs. They also find striking similarities between coral reefs and rainforests, highlighting features that enable organisms to inhabit different living spaces in this amazing ecosystem. In an inquiry investigation targeting fish feeding mechanisms, student groups participate in an experiment designed to collect data and formulate conclusions on these mechanisms. Supported by online research, students focus on unique characteristics and feeding interactions of a variety of invertebrate species and fish families common to the coral reef ecosystem.

The unit culminates with the collaborative creation of an authentic food web identifying organisms as producers, consumers or decomposers in the flow of energy (indicated by direction of arrows).



At A Glance

Each Lesson addresses HCPSS III Benchmarks. The Lessons provide an opportunity for students to move toward mastery of the indicated benchmarks.

ESSENTIAL QUESTIONS	HCPSS III BENCHMARKS	LESSON, <i>Brief Summary</i> , Duration
<p>What are the unique features of organisms that enable them to survive in the different living spaces of the coral reef habitat?</p>	<p>Science Standard 3: Life and Environmental Sciences SC.5.3.1 Describe the cycle of energy among producers, consumers, and decomposers.</p>	<p>Lesson 1: Living Spaces of the Coral Reef Habitat In this lesson students will compare a coral reef to a rainforest in order to introduce the different living spaces available in the coral reef habitat. The teacher then uses images given in a PowerPoint to engage students in observing different body shapes, and appendages of reef organisms that enable them to survive in these various reef spaces. To further investigate structures and adaptations of reef organisms the students break into groups and play a short card game where they sort the organisms into particular groupings specified by the teacher. The lesson wraps up with the students interpreting a chart and graph, comparing the features of various reef organisms.</p> <p>Two 45-minute periods</p>

ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	LESSON, <i>Brief Summary</i> , Duration
<p>What are the roles organisms play in a coral reef ecosystem?</p>	<p>Science Standard 2: The Scientific Process: SC.5.2.1: Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world. Science Standard 3: Life and Environmental Sciences SC.5.3.1: Describe the cycle of energy among producers, consumers, and decomposers SC.5.3.2: Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter.</p>	<p>Lesson 2: Everybody has a Role in a Coral Reef Students will examine coral reef ecosystems and identify different organisms that live there. They will determine the roles different organisms play and define food chains and food webs found within the reef ecosystem. One 45-minute period</p>
<p>How do the unique mouth features of different reef fish help them to feed in the coral reef ecosystem?</p>	<p>Science Standard 1: The Scientific Process: Scientific Investigation: SC.5.1.1 Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments. SC.5.1.2 Formulate and defend conclusions based on evidence.</p>	<p>Lesson 3: Hungry Reef Fish Students work in cooperative groups as they engage in an inquiry investigation of the feeding styles of various reef fish with different types of mouth parts, or feeding behaviors. Students will identify a research question/hypothesis, devise an experimental procedure to collect data to answer their question, construct a chart to compare the feeding adaptations of reef fish, and write a conclusion to complete the laboratory activity. Three 45-minute periods</p>

ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	LESSON, Brief Summary, Duration
<p>What are the characteristics of an invertebrate?</p> <p>What is the role of an invertebrate in a coral reef ecosystem?</p>	<p>Science Standard 3: Life and Environmental Sciences:</p> <p>SC.5.3.1: Describe the cycle of energy among producers, consumers, and decomposers</p> <p>SC.5.3.2: Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter</p>	<p>Lesson 4: Invertebrates on the Reef Students will do research to learn about invertebrates. They will share their information with the rest of the class.</p> <p>Two 60-minute periods</p>
<p>What are the characteristics of vertebrates?</p> <p>What vertebrates can be found in a coral reef ecosystem?</p> <p>What is the role of vertebrates in a coral reef ecosystem?</p>	<p>Science Standard 3: Life and Environmental Sciences:</p> <p>SC.5.3.1: Describe the cycle of energy among producers, consumers, and decomposers</p> <p>SC.5.3.2: Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter</p>	<p>Lesson 5: Vertebrates on the Reef Students will do research to learn about vertebrates. They will share their information with the rest of the class.</p> <p>Two 60-minute periods</p>
<p>How are the varieties of organisms that live on a coral reef ecosystem important to its functioning in terms of cycles of matter and flow of energy?</p>	<p>Science Standard 2: The Scientific Process:</p> <p>SC.5.2.1: Use models or simulations to represent and investigate features of objects, events and processes in the real world</p> <p>Science Standard 3: Life and Environmental Sciences:</p> <p>SC: 5.3.1: Describe the cycle of energy among producers, consumers and decomposers.</p> <p>SC: 5.3.2: Describe the interdependent relationships among the producers, consumers and decomposers in an ecosystem in terms of matter</p>	<p>Culminating Lesson: Coral Reef Ecosystems Students will collaborate in creating an authentic food web reflecting interactions of coral reef producers, consumers and decomposers. Direction of arrows indicate the flow of energy in the reef ecosystem and use of different colors highlight the cycling of common elements of matter.</p> <p>One 60-minute period</p>

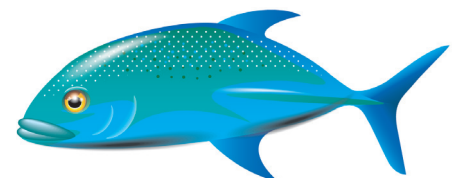
***Hawaii Content & Performance Standards III Database: "Hawaii Department of Education. June 2007. Department of Education. 17 Dec. 2007.*

Benchmark Rubric

I. HCPS III Benchmarks*

Below is a general Benchmark Rubric. Within each lesson, there are other assessment tools and additional rubrics specifically addressing the performance tasks of each lesson topic.

Topic		Scientific Inquiry	
Benchmark SC.5.1.1		Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Identify the variables in scientific investigations, explain why variables need to be controlled, and give examples of how to control variables in scientific experiments	Identify the variables in scientific investigations and recognize the importance of controlling variables in scientific experiments	Identify, with assistance, the variables in a scientific investigation or the importance of controlling the variables	Recognize, with much assistance, the variables in scientific investigations
Topic		Scientific Inquiry	
Benchmark SC.5.1.2		Formulate and defend conclusions based on evidence	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Formulate and defend conclusions that are supported by detailed evidence and make connections to the real world	Formulate and defend conclusions that are supported by evidence	Make conclusions that are partially supported by evidence	Make conclusions without evidence
Topic		Unifying Concepts and Themes	
Benchmark SC.5.2.1		Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world	Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world	With assistance, use models or simulations to represent features of objects, events, or processes in the real world	Recognize examples of models or simulations that can be used to represent features of objects, events, or processes



Topic		Cycles of Matter and Energy	
Benchmark SC.5.3.1		Describe the cycle of energy among producers, consumers, and decomposers	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain and give detailed examples of the cycle of energy among producers, consumers, and decomposers	Describe the cycle of energy among producers, consumers, and decomposers	Describe a part of the energy cycle with an example (e.g., describe one or two parts of a food chain)	Recognize an example of part of an energy cycle
Topic		Interdependence	
Benchmark SC.5.3.2		Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain and give examples of how specific relationships among producers, consumers, and decomposers in an ecosystem affect the cycling of matter	Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycling of matter	Identify a few relationships between producers, consumers, or decomposers in an ecosystem in terms of the cycling of matter	Recall, with assistance, that matter cycles in an ecosystem among producers, consumers, and decomposers

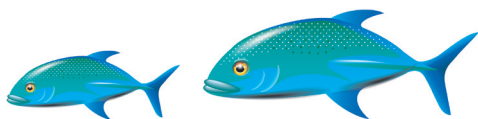
*HCPS III Benchmarks are from the Hawai'i Department of Education's Website:

<http://doe.k12.hi.us/standards/index.htm>.

II. General Learner Outcomes*

Below is a list of the HIDOE General Learner Outcomes (GLOs). Each Unit of the Lessons from the Sea Curriculum addresses the GLOs. Within some lessons, there is more specific mention of individual GLOs with specific pertinence.

- I. Self-directed Learner. (The ability to be responsible for one's own learning.)
- II. Community Contributor. (The understanding that it is essential for human beings to work together.)
- III. Complex Thinker. (The ability to demonstrate critical thinking and problem solving.)
- IV. Quality Producer. (The ability to recognize and produce quality performance and quality products.)
- V. Effective Communicator. (The ability to communicate effectively.)
- VI. Effective and Ethical User of Technology. (The ability to use a variety of technologies effectively and ethically.)



Science Background for the Teacher

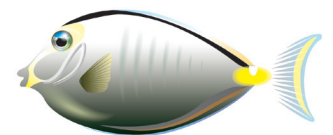
Note: Bolded words found within this section are defined in the Science Background for the Teacher Glossary. The footnotes refer to the references found in the Science Background for Teacher- Bibliography at the end of this section.

What is the difference between hard and soft coral? What are examples of hard corals common to Hawai'i?¹ (Lesson 1)

All corals are invertebrate animals in the phylum Cnidaria. Other animals in this phylum include anemones and jellyfish, and all Cnidarians are grouped because they possess specialized stinging cells called **cnidocytes (NYE-dough-sites)**. Corals in particular can further be classified as either hard or soft based on three major differences: 1) their arrangement and number of tentacles around the mouth, 2) their association with symbiotic algae called **zooxanthellae (zoo-zan-THEE-lay)**, and 3) the presence and/or composition of their skeletons.

Soft corals are often referred to as **octocorals**, because of the presence of eight distinct tentacles surrounding the mouth of each individual **polyp**. Soft corals are primarily **planktivores**, meaning they feed on the small animals and plants floating in the water column. As a result, their polyps are often extended during the day for feeding, giving them their characteristic soft, fleshy appearance. Soft corals can also be found in **symbiosis** with a single-celled algae termed zooxanthellae, but do not rely on this algae as a primary source of food energy as most hard corals do. Most soft corals secrete flexible skeletons made from a protein called **gorgonin (gore-GO-nin)**, while others secrete discrete amounts of **calcite** (a form of calcium-based mineral) to form **sclerites (SCHLER-ites)**, semi-fused skeletal fragments. Some soft corals are truly soft, containing no skeleton structure at all. Because soft corals do not form hard skeletons, they are not involved in reef formation, but can be dominant features in coral reef ecosystems around the world. The Hawaiian endemic blue octocoral (*Anthelia edmondsoni*) is a truly soft coral with no skeleton. It can be found primarily in shallow water as small tufted blue colonies. Snowflake coral (*Carijoa riisei*) is a soft coral that was accidentally introduced sometime in the 1970s, and is becoming common on pier pilings and current-exposed vertical walls. In Hawai'i, soft corals are generally uncommon, or found more often in deeper waters.

Hard corals are often referred to as *reef-building* corals, and although not all hard corals build reefs, all reef builders are hard corals. Reef-building hard corals are primarily characterized by having skeletons composed of **aragonite**, a calcium carbonate mineral. Coral polyps secrete aragonite in such amounts that they form the large reef structures that support a whole community of species. Hard corals tend to have arrangements of tentacles in multiple groups of six, as opposed to always eight for soft corals. All *reef-building* hard corals have an obligate relationship with zooxanthellae algae and, as such, all can be found with extreme densities of this single-celled algae residing within coral tissues. Through photosynthesis – the conversion of sunlight into food energy – zooxanthellae supply up to 95% of a reef-building coral's total food energy requirements. As a result, most reef-building corals do not depend on capturing food and, therefore, rarely feed. It is this obligate symbiosis between the coral and the algae that is responsible for the immense growth of coral reef structures.



Common hard corals found in Hawai'i include:

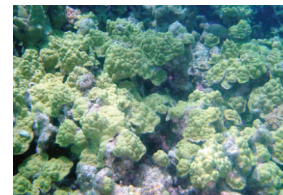
Finger coral (*Porites compressa*) *pōhaku puna*:

This coral is aptly named because of its stalky branches forming finger-like shapes that dominate vast swaths of reef in the reef slope zone. The finger corals grow fast in locations where wave action is mild and light penetration is sufficient. They quickly out-compete other species, becoming the dominant coral on the reef slope zone.



Lobe coral (*Porites lobata*) *pōhaku puna*:

Related to the finger coral, lobe coral is a massive, mounding coral. It grows slow, forming large lobes instead of discreet fingers, and can reach great sizes covering several meters or more. Because of its mounding shape, lobe coral can withstand high wave action and predominates in the reef bench zone where the faster growing, out-competing finger coral cannot grow.



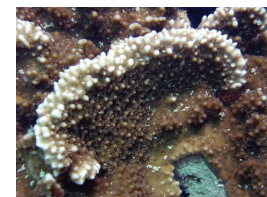
Cauliflower coral (*Pocillopora meandrina*):

This coral has sturdy, thick and flat leafed branches and grows in small, discreet tufted colonies. It is most common in high energy wave areas, but can be found in all three reef zones.



Rice coral (*Montipora sp*):

This coral takes on a variety of forms, growing vertically into fragile finger-like projections in calm, shallow well-lit habitats of the reef slope zone. It can also grow into large protruding plate-like structures in calm, deeper, less well lit lower slope zones to obtain sunlight.

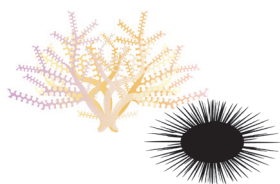


For additional information, see www.coralreefnetwork.com/marlife/corals/corals.htm

What is the chemical composition of a coral reef? How does a coral reef form?? (Lesson 1)

All reef-building corals that live in symbiosis with zooxanthellae are called **hermatypic** corals. These corals sequester dissolved calcium ions from the seawater and combine the calcium ions with carbonate ions to form **aragonite** minerals that are deposited by epidermal cells to build coral skeleton and eventually the reef.

All corals, whether hard or soft, reproduce by both sexual and asexual strategies. Reef-building corals are **colonial** organisms that form **colonies** through **asexual reproduction**. Asexual reproduction can occur in many forms of which the most common types will be discussed here. To understand the formation of coral reefs, we must start with an individual coral polyp. **Budding** and **fission** occur when a single coral polyp slowly cleaves itself in half to form two distinct polyps that are genetically identical. When polyps continue this process, they eventually form a coral colony of many genetically identical individuals, which are also termed clones. Although coral colonies start small, some of them, over time, can become massive structures as they continue to reproduce clones through budding. **Fragmentation**, another type of asexual reproduction, occurs when wave action, or some other disturbance, causes a portion of the coral colony to become separated, or break off the original parent colony, and continues to grow on its own. Over time, these modes of asexual reproduction function to create numerous coral colonies that collectively form a coral reef.



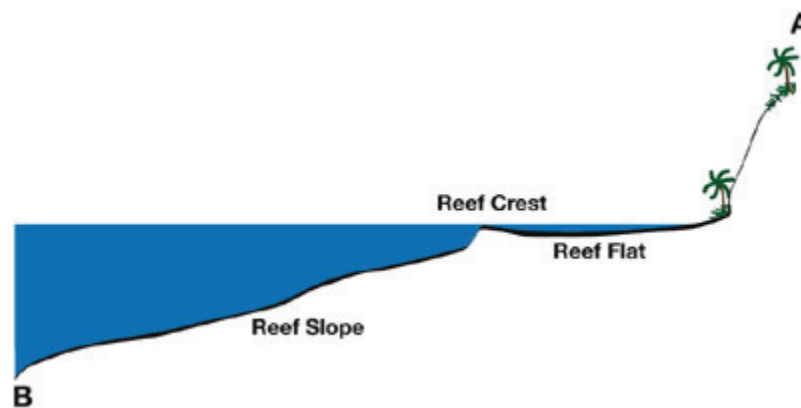
Sexual reproduction also exists in corals, and takes place in colonies whose polyps become sexually mature. Sexual reproduction in corals is not easy considering they are **sessile** animals. They get around this limitation by releasing their **gametes** into the water column for external fertilization, a process termed **broadcast spawning**. Broadcast spawning is usually synchronized between individual species, and often involves a seasonal, monthly, or daily component. Corals can be **simultaneous hermaphrodites**, meaning that a polyp can release both eggs and sperm as bundles, or they can be **gonochoric (gone-o-KOR-ik)**, releasing either eggs or sperm, but not both. For example, the endemic Hawaiian mushroom coral *Fungia scutaria* is a gonochoric species that spawns in the early evening within 1–3 days of a full moon in the summer months of June–September. After fertilization occurs, the coral larvae, also called **planula (PLAN-u-la)**, may stay in the water column, drifting with the plankton until they find a suitable habitat to settle and metamorphose into a juvenile coral polyp, a process termed **larval recruitment**. Once the planula has settled and metamorphosed, the single polyp will soon start to reproduce asexually by budding, creating a new colony, and the process starts again.

Important mechanisms in the formation of a coral reef include the dispersal of planktonic planula, and the **rafting** of small colonies that essentially *hitch* a ride by settling on floating marine debris. Some coral planula can be in the plankton for up to 100 days, allowing plenty of time to find new habitats. Rafting in particular is thought to be key in the arrival of many of Hawai‘i’s marine organisms. Bottles, sandals, pumice stone, wood, and many other types of floating objects have been found to host small coral colonies, as well as other sessile organisms like algae and sponges, that have settled on the object.

What types of reef formations exist, and how do they change over time?³ (Lesson 1)

There are three major types of reef formations that develop around islands: fringing reefs, patch reefs, and barrier reefs. **Fringing reefs** develop along shoreline margins of islands, forming a *skirt* around the base of the landmass. Corals and other reef-building organisms quickly colonize the available shallow waters that surround the island. Once all the available horizontal space is colonized, corals begin to grow upward toward the sun until they reach just below the sea surface, maximizing as much space as possible for growth.

Most fringing reefs can be further divided from the land to the sea into the reef flat, reef crest, and reef slope. The **reef flat**, which is located directly adjacent to land, often receives large amounts of rain runoff and, as a result, has low coral diversity. The **reef crest** is the most exposed part of the fringing reef because of its exposure to high-energy waves. The **reef slope** extends seaward below the reef crest and has the highest coral abundance and diversity. Fringing reefs are a dominant feature surrounding parts, or all of each of the Main Hawaiian Islands.



A **barrier reef** is a fringing reef that has been separated from land due to island subsidence, or sinking into the sea, and encloses a **lagoon** between the reef and the subsiding island. Over time, numerous patch reefs can form within the lagoon. **Patch reefs** are isolated coral reef formations that can vary greatly in size. Corals within the lagoon tend to have slower growth due to less food availability, and the influence of sediment inputs and freshwater runoff from land. Coral growth is rapid on the seaward edge of the barrier reef because food is plentiful and conditions are stable compared to the landward facing slope of the barrier reef. An excellent example of a barrier reef is found on O‘ahu in Kāne‘ohe Bay. The barrier reef sheltering Kāne‘ohe Bay is the northern most barrier reef in the Pacific. It is not considered a *true* barrier reef because it is not composed solely of reef material. A landslide that occurred over one million years ago on the eastern side of the Ko‘olau volcano initially formed the bay. Coral reef organisms started to colonize the volcanic rock that was pushed into the sea from the landslide and, as O‘ahu subsided, coral growth kept up with the subsidence, forming the barrier reef we see today.

As islands continue to sink from subsidence and eventually disappear beneath the sea surface, atolls will form as long as the rate of coral growth surpasses the rate at which the island is subsiding. **Atolls** are low-lying islands comprised of a ring of coral reef enclosing a lagoon. The most visible structure of the atoll is the ring of coral reef enclosing the shallow lagoon. Most of the Northwestern Hawaiian Islands are low islands that are characterized by atolls; for example, the Midway Atoll, Pearl and Hermes Atolls, and Kure Atoll.

For aerial images of the Northwestern Hawaiian Islands, visit

<http://www.oceandots.com/pacific/nwhi> and <http://hawaiiatolls.org/maps/index.php>

The relative ages of islands can be compared based on the type of reef structure surrounding the island. Younger islands tend to have fringing reef structures, or barrier reef structures, and are usually high islands because of the amount of volcanic landmass still present above the surface. Older islands that have little to no volcanic landmass left above the sea surface are usually low islands. They are composed primarily of sand or coral material, and have lagoons enclosed by a barrier reef. Low islands are considered atolls when the landmass is no longer above the sea surface.

For additional information concerning the different types of coral reef formations, see

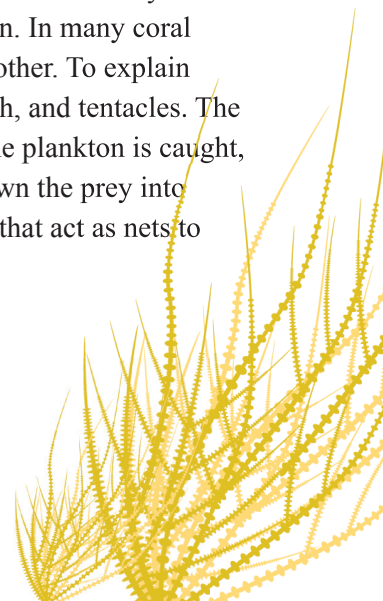
<http://oceanservice.noaa.gov/education/kits/corals/welcome.html>

www.starfish.ch/reef/reef.html

www.coris.noaa.gov/about/what_are/

How do corals obtain food?⁴ (Lesson 1)

While most hermatypic (hard, reef building) corals receive a majority of their food energy requirements from symbiotic zooxanthellae (see above), hermatypic corals, and other non-symbiotic corals also feed on plankton. In many coral colonies, food resources are often shared among individuals because they are connected to one another. To explain this, let's start by describing the simple body plan of a coral polyp. It consists of a stomach, a mouth, and tentacles. The tentacles act as arms waving in the surrounding waters to catch tiny plankton that float by. Once the plankton is caught, the tentacles move it down to the mouth and into the stomach where digestive chemicals break down the prey into particles that can be absorbed by the cells lining the stomach. Corals can also release mucus films that act as nets to capture small food particles.



The coral is able to withdraw the mucus net back into the mouth for digestion. Nutrients are shared among the various coral polyps in a colony through connective tissues called the **coenosarc (SEEN-o-sark)**. A colony, therefore, has many mouths that are capturing prey and food particles to meet the metabolic requirements of the whole colony.

What are food chains and food webs?⁵ (Lessons 1, 2, and 3)

Food chains are simplistic linear models that describe the feeding relationships among various species of organisms in an ecological community. They are useful for understanding the different trophic levels to which organisms belong in the ecological community. Arrows are used to represent the transfer of energy from each level. An example of a food chain in a coral reef community would look like this:

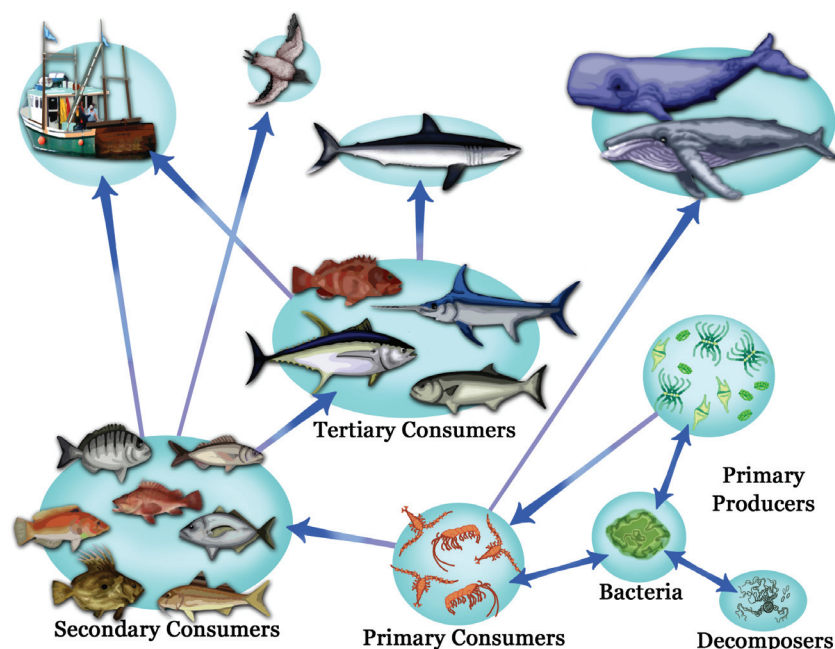
algae → sea urchin → octopus → eel → ulua

In this example, the algae represent the **primary producers**, **autotrophic** organisms that make their own food by converting the energy from sunlight into food energy. The sea urchin is an herbivore and is considered to be a primary consumer in this example. **Consumers** are **heterotrophic** organisms that cannot produce their own food and must obtain food by eating other things; herbivores eat plants or algae in this case, and carnivores eat herbivores or other types of carnivores. The octopus is a carnivore, and because it is the first carnivore in the food chain, is a primary carnivore. The eel is a secondary carnivore. And, finally, the ulua is the **top predator** in this food chain example because no other consumer eats it.

In a given ecosystem or community, many different food chains can be combined into **food webs** that give a more realistic picture of the feeding relationships. Considering the food chain described above, in reality, not only is algae eaten by sea urchins, but also by a variety of different species of fish and other invertebrates. In a food web diagram, many arrows would arise from the algae and point to all the different organisms that feed on it. Likewise, other types of consumers eat sea urchins, octopuses, and eels; many arrows would be present to account for the feeding relationships of all the organisms in the coral reef community.

To view an image of a food web see below or visit

http://www.arctic.noaa.gov/images/arctic_marine_food_web.jpg



How does energy flow through the food chain?⁶ (Lessons 1, 2, and 3)

As previously mentioned, trophic levels group species into broad categories based on their energetic contribution (as a food resource) to the community. This can be represented by a simple food chain. Each community has different energy requirements and, as a result, the flow of energy through the trophic levels (i.e. food chains) of one community will look different from another community. The following example is a general model. *Primary producers* are the basis of all food chains, and their net primary productivity equals the energy available to all consumers in the community. *Primary consumers* are those that eat the primary producers. They can take the form of herbivores or decomposers, and the energy available within primary producers is first transferred to these two trophic levels. Following energy through the path of the herbivore, of the energy that is ingested (i.e. eaten), only a small fraction is actually assimilated (absorbed in the gut), and most of the energy is unused and wasted. Of the small fraction of the energy that is assimilated by the herbivore, a large part of it is used for maintaining life processes (respiratory heat). As a result, only a small fraction of energy is actually transferred from an herbivore to a secondary consumer in the form of new **biomass**.

The small amount of energy that actually gets transferred from herbivore to carnivore ends up representing only a small fraction of the energy that was available within the base trophic level of the primary producers. Each successively higher trophic level will have less and less energy available. In the majority of communities, this can be reflected in the relative abundance (number of organisms) and total biomass (amount of living matter per unit area) of organisms representing the different trophic levels. For example, in a terrestrial grassland community, plants will be very abundant with high biomass, followed by lower amounts of herbivores like mice, grasshoppers, and deer, and even less of carnivores like owls, foxes, and wolves. In the Northwestern Hawaiian Islands, however, a more unusual situation exists in the coral reef community. This ecosystem is predator dominated (higher level consumers) in terms of abundance, with more ulua, sharks, and groupers than lower-level carnivores and herbivores. This is the opposite of the general trend, and reflects how variable the trophic relationships among species in different communities can be.

What are the examples of producers, consumers, and detritivores (decomposers) in Hawaii's reef ecosystems?⁷ (Lessons 1, 2, and 3)

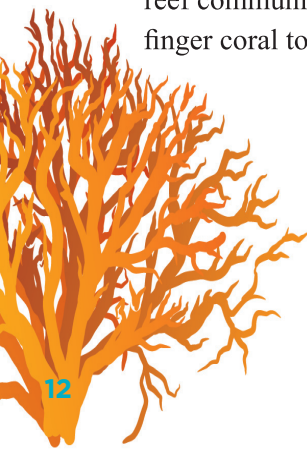
Hawai'i's coral reef ecosystem is extremely productive despite its existence in relatively low-nutrient waters. The most abundant primary producers on the reef are the single-celled zooxanthellae that reside within the coral tissues. There are many other primary producers. Examples of native macroalgae include:

Ulva fasciata (limu palahalaha):

This common, edible algae is known as *sea lettuce*. It resides in the intertidal on rocks, in tide pools, and on reef flats.

Dictyosphaeria cavernosa:

The common name for this native algae is *bubble algae*, and it is found as convoluted mats attached to rocks and coral rubble in shallow reef flats or tidepools. When nutrients are abundant, bubble algae can overgrow and kill finger coral. In *Kāne'ōhe Bay*, during the 1970s, excess nutrients from the old sewage outfall allowed this algae to dominate the reef communities in the bay. Since the removal of the outfall, it has slowly started to decline in abundance, allowing finger coral to recover.



Halimeda opuntia:

This calcareous algae is found primarily in the subtidal zone attached to coral underhangs or rocks. This algae is a major producer of sand in tropical reefs due to its formation of a calcareous skeleton.

For additional information concerning native algae, visit

<http://www.hawaii.edu/reefalgae/natives/sgfieldguide.htm>

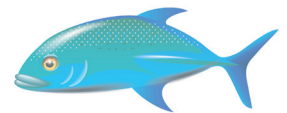
There are numerous consumers, and they can be classified into feeding guilds or groups of species that exploit the same food resources.

Detritivores and **scavengers** feed on loose food particles in the sand or rubble, or search for dead or dying organisms, their preferred food staple. Lobsters, sea cucumbers, brittle stars, some crabs, and shrimp, and even some types of sharks and wrasses, can be considered in this food guild.

Herbivores feed on the algae growing on the reef. Numerous species of angelfish, damselfish, triggerfish, parrotfish, and even sea turtles can be classified into this feeding guild. Invertebrate species like sea urchins, limpets, and cowries are also herbivores. They can be further characterized by the way in which they feed. For example, sea urchins are considered grazers, feeding on specific patches of algae using scraping teeth-like mouthparts.

Carnivores prey and consume other live animals. Species of butterflyfish, sharks, and jacks, like ulua, hawkfish, mantis shrimp, and cone snails, make up this group. They, too, can be further grouped into corallivores (those that eat coral), piscivores (those that eat fish) and molluscivores (those that eat molluscs, or snails).

Omnivores eat both plant and animal materials. Species of triggerfish, Moorish Idols and Fan-tail filefish are grouped into this category.



What is the role of detritivores, decomposers, and scavengers in the reef ecosystem?⁸

(Lessons 2)

Detritivores are **benthic** organisms that live in, or on, the sandy floor of the reef. They either sift through the sand, or ingest the sand in an effort to separate out organic material like bits of algae or other food particles. **Scavengers** are often **nocturnal** feeders that come out at night to search for dead, dying, or decaying organisms. Detritivores and scavengers help keep the reef clean of excess, unused debris. They help with decomposition by breaking apart organic matter into smaller and smaller parts for the microbial decomposers. **Decomposers** are bacteria that break down decaying material and waste products and convert organic nutrients to inorganic nutrients that primary producers can use for growth. These feeding guilds play important roles in the food web by recycling the energy left in waste and dead materials.

A close relationship exists between primary producers and decomposers in that the amount of organic matter made available to decomposers in an ecosystem is closely tied to the levels of primary productivity. Likewise, the amount of nutrients made available to primary producers is related to the amount of decomposition. Primary producers rely on the decomposers to supply nutrients, and decomposers rely on both producers and consumers to make organic matter available. Most of the primary production available to the system at any time is not necessarily consumed by herbivores, but instead, is transferred to this *detrital food chain*. Especially in marine ecosystems, primary producers like phytoplankton have such large growth rates and high turnover that many of them die off and sink to the sea floor, or dissolve into nutrients in the water column before ever being eaten.

What are the unique features of organisms that enable them to survive in the different living spaces of the coral reef habitat?⁴ (Lessons 3)

a) How do the unique mouth features of different reef fishes enable them to feed in the coral reef habitat?

Fishes living in the reef habitat are often dependent on corals as a food source, and have evolved specialized mouth features that enable them to efficiently feed. Some of the unique modifications in mouth shapes found in common Hawaiian reef fishes are described below. Images of common Hawaiian reef fishes can be found in Lesson 4.

Butterflyfishes (*Chaetodontidae*):

These brightly colored reef fish have very short, small mouths that allow them to graze on algae growing on the reef, or small invertebrates like coral polyps and anemones, and are considered **omnivores**. Some have very specialized, long snouts they use to reach into the coral and eat coral polyps (e.g., Longnose butterflyfish, *lauwiliwilinukunukuoi* 'oi).

Damselfishes (*Pomacentridae*):

These fish are often found in small groups hovering right above the reef in search of tiny animals and plants floating in the **plankton**. They have short snouts, but relatively big mouths that allow them to suck the plankton out of the water column (e.g., sergeant major fish, *mamo*).

Moray Eels (*Muraenidae*) *puhi*:

These fish are **carnivorous** ambush predators that wait in cracks and crevices in the reef to capture a passing prey. They possess big sharp teeth and have large mouths.

Goatfishes (*Mullidae*) *weke* 'ā:

These fish have their mouths positioned on the bottom of their snouts, and they possess two barbells or feelers for searching the sandy bottom for worms and other soft-bodied invertebrates that dwell in the sand.

Parrotfishes (*Scaridae*) *uhu*:

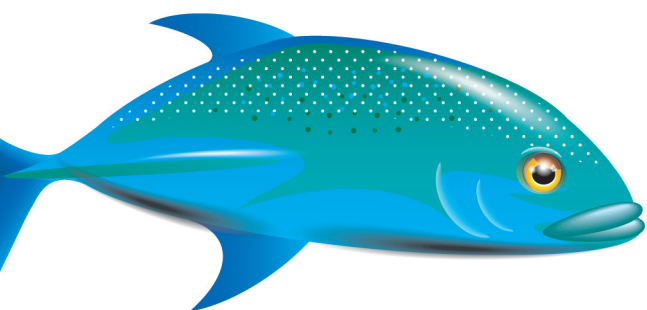
These fish have large teeth that are fused together, and strong jaws to enable them to scrape algae and coral from the reef. They are primarily herbivores.

For more information see: <http://www.fishid.com/learnctr/fisheat.htm>

b) What are the unique structures (body features) of reef animals that help to protect them in the coral reef habitat?

Life on a reef can be dangerous for many organisms, as there is always a chance a predator may be lurking. The evolution of defense mechanisms has resulted in many unique features that help reef organisms survive. Examples of defense mechanisms in common Hawaiian reef fish follow:

Surgeonfishes are named so because of the knifelike spines or scalpels on either side of the base of their tails. One swipe of the tail can slash an enemy or intruder.



Butterflyfishes have many spines disguised in their fins. They use very vivid coloration to announce their potential danger to a predator or enemy. Many different types of reef fish, like the millet seed butterflyfish (*lauwiliwili*), have big false eye spots near their tails to confuse predators concerning their actual size.

Porcupine pufferfishes not only inflate their bodies with water to avoid being eaten, but they also have large spikes that poke out from their bodies to prevent capture.

Scorpionfishes use coloration to blend into their habitat, effectively hiding themselves by looking like a part of the reef. Because these fish are ambush predators, they also use this advantage to capture unknowing prey. They also have poisonous spines in their fins.

Sea snails and **nudibranchs** use bright coloration patterns to warn potential predators that they may taste bad or are poisonous.

Although not a fish, corals, too, have specialized defense mechanisms (previously discussed) called **nematocysts**, stinging cells that are released if they are harassed by predators. Since corals cannot move or shake off any sediment or other particles that may fall on them, they continually shed mucous to slough off anything that might try to settle on them.

Other reef-associated invertebrates, such as crabs, have large claws that they use to defend themselves against predators; they also use these claws to catch food. Certain types of hermit crabs often keep anemones on their shells for protection. The anemones have the same types of special stinging cells as corals in their tentacles. When a predator tries to eat the hermit crab, it gets a mouthful of **nematocysts** instead.

What other organisms visit the reef?⁹ (Lessons 4 & 5)

Many organisms do not permanently reside within the reef, but occasionally visit the reef to obtain food resources or seek shelter. Turtles can often be found grazing on the algae that grows on the reefs. Large predators, like tiger sharks, often cruise reefs in search of turtles to prey upon. Female hammerheads use the reef as birthing grounds for their young. Occasionally, dolphins can be spotted in the reefs searching for food. Manta rays are infrequently seen gracefully swimming along the reef shallows to filter-feed on plankton. Monk seals in the Northwestern Hawaiian Islands utilize the reefs to search for crustaceans and fish to eat. Humans also utilize the reef for food resources and recreational purposes.

How does biodiversity help maintain a healthy reef ecosystem, and how does a reduction in biodiversity affect the reef ecosystem?¹⁰ (Culminating Lesson)

Biodiversity is the variability of life forms found within a given ecosystem. In general, high biodiversity is a sign of a healthy ecosystem, while low biodiversity often indicates an unhealthy ecosystem. This is especially true on reefs because, without the corals, biodiversity on a reef would likely be very low. Corals are the most important organisms on a tropical reef because their structure creates numerous and varying habitats that allow a variety of *niches* to exist in a typical reef community.

A **niche** describes the functional role of a species in an ecosystem, and the resources provided for those organisms to survive and reproduce. Because the structure and resources of the coral reef facilitate a large number of niches, reefs typically harbor extremely high biodiversity, and the interactions of species occupying these niches function in maintaining a healthy reef ecosystem. A reduction in biodiversity can disrupt the balance of these interactions, resulting in a health-compromised ecosystem. For example, reefs that are influenced by high levels of terrestrial runoff, pollutants, or invasive species often show a decrease in biodiversity as the health of the reef is reduced. In *Kāneʻohe Bay*, large amounts of sewage deposited into the waters in the 1970s corresponded with high levels of nutrients in the water, leading to an increase in the growth of the native bubble algae (see above). The bubble algae became so abundant that it dominated the reefs in the bay, smothering the live coral. The lack of coral resulted in fewer species able to inhabit the reef, thereby reducing biodiversity. It is also likely that over fishing exacerbated the problem of algal overgrowth in the bay. Over fishing can cause fewer herbivores on the reef to keep rapidly growing algae levels at bay, allowing the algae to grow uncontrollably.

A reduction in biodiversity on the reef is often a sign of other negative effects that may be influencing the reef ecosystem. For example, in comparing the Northwestern Hawaiian Islands to the Main Hawaiian Islands, there are measurable differences in the numbers and abundances of different species that reside in either reef ecosystem. Large predatory fish species like sharks, jacks, and groupers are found in relatively low abundance in the Main Hawaiian Islands. In the Northwestern Hawaiian Islands, these reef predators are exceedingly common, and often swim in large groups around the reefs. The reduction in biodiversity in the Main Hawaiian Islands is likely a result of human impacts like fishing, the introduction of invasive species, pollution, and runoff.

Science Background for the Teacher Glossary

algae: simple one celled or many celled plants that lack true roots and leaves.

aragonite: a form of calcium carbonate mineral.

asexual reproduction: when an organism produces a clone of itself; does not involve the fusion of sex cells or genetic material.

atolls: ringed coral reef island enclosing a lagoon.

autotrophic: describes an organism that can synthesize its own food.

barrier reef: a coral reef structure that is parallel to a land mass and encloses a lagoon.

benthic: occurring on the bottom of a body of water.

biodiversity: the variety of species in an ecosystem.

biomass: the amount of living matter per unit of area.

broadcast spawning: a reproductive strategy whereby gametes are externally deposited in the water column.

budding: type of asexual reproduction where a portion of the parent organism splits off and grows into a complete organism.

calcite: a form of calcium carbonate mineral found in most soft corals.

carbon: basic element found in organic molecules (e.g., carbohydrates like sugar and starch, inorganic molecules like carbon dioxide).

carnivores: organisms that eat animals.

clones: genetically identical organisms of the same species.

colonial: organisms whose individuals grow in groups or colonies.

colonies: groups of individuals living together, usually genetically identical, asexual clones.

consumers: organisms that must find and eat food and cannot make it themselves.

decomposers: organisms that return nutrients into ecological cycles by breaking down dead organic material.

detritivores: organisms that preferentially feed on decaying or dead organic material.

ecosystem: environment of an organism that allows it to survive and reproduce.

fission: type of asexual reproduction in which an organism splits itself in half to produce two genetically identical individuals.

food chain: a series of organisms linked by the order in which they eat and are eaten by one another.

food webs: diagrammatical representation of feeding relationships and the flow of energy in a community or ecosystem.

fragmentation: breaking up of a large whole into smaller parts.

fringing reefs: coral reefs that form directly adjacent to a land mass.

gametes: sperm and egg cells.

gonochoric: reproductive mode in which broadcast spawners release either eggs or sperm but not both.

gorgonin: a protein produced by soft corals that acts as an internal skeleton.

herbivores: organisms that eat plant material.

hermatypic: refers to symbiosis with zooxanthellae.

heterotrophic: describes organisms that must find and consume external food material and cannot make their own food.

lagoon: a body of water isolated from the open ocean by coral reef structures.

larval recruitment: describes the transition from a planktonic larvae that lives in the water column to a juvenile organism that settles out of the water column to live its life in its adult habitat.

niche: the ecological role of an organism in a community; the utilization of abiotic and biotic resources in an environment by an organism that allows it to survive and reproduce.

nitrogen: common element found in proteins / amino acids. Nitrogen must be “fixed” by bacteria before it is available for photosynthetic organisms to create more amino acids.

nocturnal: heightened activity during the night.

octocorals: soft corals that do not build reefs.

omnivores: organisms that eat both plant and animal material.

organism: a living thing.

oxygen: basic element released by plants in photosynthesis and used by organisms in cellular respiration.

patch reefs: isolated coral reef structures that can vary in size and are usually found inside lagoons.

planktivores: organisms that feed on plankton in the water column.

planula: coral larvae.

polyp: individual body form consisting of tentacles, a mouth and stomach.

predator: organism that catches and eats organisms or another species.

prey: organism that is caught and eaten by a predator.

primary producers: organisms that comprise the base of the food chain; often these are plants and algae in sun-driven ecosystems.

producer: a green plant or plant like organism that can make food out of carbon dioxide and structures.

rafting: a method in which organisms can disperse by attaching themselves to a floating object.

reef crest: area of high wave energy on the fringing reef.

reef flat: shallow, flattest part of the reef susceptible to sedimentation and run-off.

reef slope: area of high coral cover and moderate to low wave energy on the fringing reef.

scavengers: organisms that look for and feed on dead, decaying or waste material.

sclerites: semi-fused calcite fragments found in soft corals.

sessile: organisms that are permanently attached to a surface and cannot move from it.

simultaneous hermaphrodites: organisms that produce both eggs and sperm at the same time.

substrate: a surface on which an organism grows or is attached.

symbiosis: a close association of two organisms, often living together.

top predator: an organism at the top of the food chain with no predators.

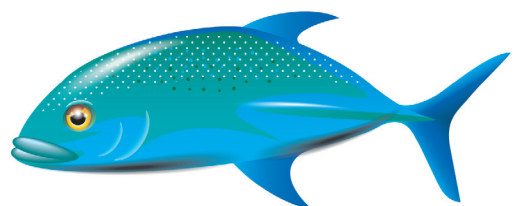
trophic level: the feeding position in a food chain (i.e., plants (primary producers) occupy the first trophic level in most terrestrial food chains).

zooxanthellae: single-celled algae that live inside the tissues of hermatypic corals and other invertebrates.

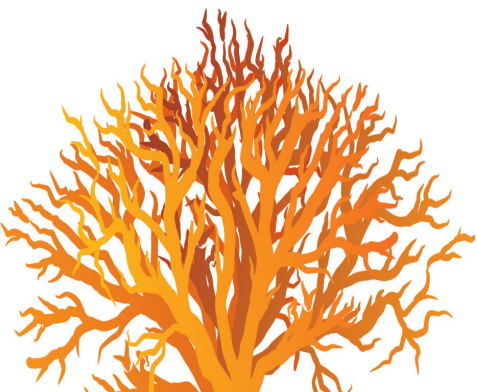
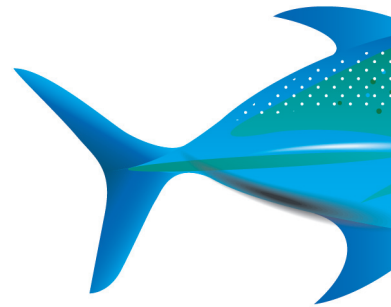
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NOAA Resources

Below is a list of resources compiled by the Outreach Education Office of the National Oceanic and Atmospheric Administration. The science standards and the ocean literacy principles addressed in this unit were used as a guideline in selecting the following resources. To access the print resources listed below, contact NOAA's Outreach Education Office directly:



Outreach Unit
NOAA Office of Public and Constituent Affairs
1305 East West Highway #1W514
Silver Spring, MD 20910
Phone: (301) 713-1208
Email: NOAA-OUTREACH@noaa.gov
<http://www.education.noaa.gov/>

Resources:

- Earth and Sky Podcast by Ku‘ulei Rodgers on Corals & Ocean acidification Release Date - February 15, 2010
(Click the link below).
<http://earthsky.org/biodiversity/kuulei-rodgers-says-hawaiis-corals-are-dissolving>



OCEAN LITERACY ESSENTIAL PRINCIPLES

5. The ocean supports a great diversity of life and ecosystems.
 - 5a. Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
 - 5c. Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
 - 5d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
 - 5e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Lesson 1: 5a. 5c. 5d. 5e.

Lesson 2: 5a. 5d.

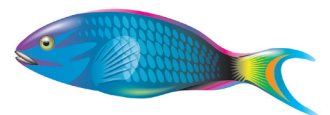
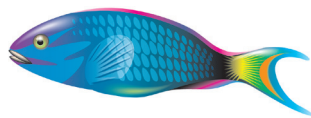
Lesson 3: 5d.

Lesson 4: 5d.

Lesson 5: 5d.

CLIMATE LITERACY ESSENTIAL PRINCIPLES

There is no appropriate alignment of Climate Literacy Essential Principles to the unit lessons.



NOAA Marine Science Career - Case Studies

Kathy Chaston - PhD

Coral and Coastal Management Specialist
NOAA Coral Reef Conservation Program

Protecting corals! Let's meet Dr. Kathy Chaston who is going to tell us about her job as a coral and coastal management specialist. Kathy currently works for NOAA's Coral Reef Conservation Program.



What does a coral and coastal management specialist do?

As part of my job, I manage and protect coral reefs so they might survive for years to come. I get to work with coral reef managers, who are people who look after coral reefs, and coral reef scientists. We all work together to learn more about the corals, find out what is damaging them, and figure out how to stop the damage. Areas with polluted water actually make the corals sick. As a coastal management specialist, I have to find a way to stop the pollution and dirt from flowing onto the reef. The waste that washes down streams and storm drains can smother coral reefs. It is part of my job to find ways to help keep trash and waste out of storm drains and waterways, so we can help save our corals.



How did you become interested in protecting corals?

I grew up in Australia where most of my childhood was spent exploring the beach and swimming in the ocean. My parents are nature lovers and have always surrounded me with science. As a teenager, I grew passionate about marine mammals and knew that I wanted to do something to protect their environment. That passion for marine mammals and encouragement from my family lead me to pursue a degree in environmental science at the University of Queensland in Australia. While I was a student there I worked for an environmental consultant for two years and then worked full-time with them after graduation. Later my cousin Lem, a marine biologist who was my role model and mentor, encouraged me to pursue my doctoral degree in marine botany. Since earning my PhD, I have worked for a community non-profit organization in Yap, I have been a Coastal Resource Manager in Palau, and I coordinated a coral reef project at the University of Hawaii.

What advice do you have for students who want to work in your field?

If you are willing to explore and have adventures, there are many exciting opportunities in this line of work. Be sure to study science, try to volunteer with environmental groups and pursue internships where possible. Then when it comes time to choose a career make sure it is something that you really care about, it makes work so much more fun! That is what I did and my career has allowed me to live and work in many cool places: Australia, Micronesia, and Hawaii. One of the coolest things I have done happened in Palau when I got the chance to swim in a marine lake called ‘Jellyfish Lake’ that was filled with non-stinging jellyfish. Another experience that I will never forget was when I got to swim with a pod of wild dugongs in Moreton Bay, Australia.

What things can students do to protect coral reefs?

One thing people can do to protect coral reefs is to conserve water. The less water you use, the less runoff and wastewater eventually flows into the oceans. Also, keep trash and yard waste out of storm drains and waterways because “What’s on the land today could be on our reefs tomorrow.”

Glossary of Cooperative Learning Techniques

In an effort to maximize student engagement and learning, the NOAA Sea Earth and Atmosphere curricular resources were designed using cooperative learning techniques. This guide defines the expectations for implementation of each technique.

What is Cooperative Learning?

Cooperative learning may be broadly defined as any classroom learning situation in which students of all levels of performance work together in structured groups toward a shared or common goal. According to Johnson, Johnson and Holubc, (1994): “Cooperative learning is the instructional use of small groups through which students work together to maximize their own and each other’s learning.” In classrooms where collaboration is practiced, students pursue learning in groups of varying size: negotiating, initiating, planning and evaluating together. Rather than working as individuals in competition with every other individual in the classroom, students are given the responsibility of creating a learning community where all students participate in significant and meaningful ways. Cooperative learning requires that students work together to achieve goals which they could not achieve individually.

Jigsaw

To Jigsaw materials refers to the use of a strategy in which each student on a team receives only a piece of the material that is to be learned in which that student becomes the “expert.” Once the material is learned each member of the team takes a turn teaching the other members their assigned content. This type of dynamic makes the students rely on the other members of their team to learn all of the material.

Think-Pair-Share

This four-step discussion strategy incorporates wait time and aspects of cooperative learning. Students (and teachers) learn to LISTEN while a question is posed, THINK (without raising hands) of a response, PAIR with a neighbor to discuss responses, and SHARE their responses with the whole class. Time limits and transition cues help the discussion move smoothly. Students are able to rehearse responses mentally and verbally, and all students have an opportunity to talk.

Numbered Heads

This structure is useful for quickly reviewing objective material in a fun way. The students in each team are numbered (each team might have 4 students numbered 1, 2, 3, 4). Students coach each other on material to be mastered. Teachers pose a question and call a number. Only the students with that number are eligible to answer and earn points for their team, building both individual accountability and positive interdependence.

KWL Chart

A pre-assessment tool consisting of three vertical columns. Students list what they “**K**now” about a topic. What they “**W**ant” to know about a topic. The last column students share what they have “**L**earned” about a topic.

KWL CHART

Be sure to *bullet* your list.

Use *content words* only (nouns, verbs, names of people and places, dates, numbers, etc.).

WHAT DO I K NOW?	WHAT DO I W ANT TO KNOW? or WHAT DO I W ANT TO SOLVE?	WHAT HAVE I L EARNEED?
•		•

Role Cards

Assign students to cooperative learning groups. Once students are in their groups the teacher will hand out premade role cards that will help each member of the group contribute to the completion of the given task. Before roles are assigned, the teacher should explain and model the task as well as the individual roles for students so that they know and understand how his/her individual role will contribute to the success of the group completing the task. When this technique is used, taking on a different role will aid in student proficiency.

Example of role cards:

Role Card #1

Facilitator:
Makes certain that everyone contributes and keeps the group on task.

Role Card #2

Recorder:
Keeps notes on important thoughts expressed in the group. Writes final summary.

Role Card #3

Reporter:
Shares summary of group with large group. Speaks for the group, not just a personal view.

Role Card #4

Materials Manager:
Picks up, distributes, collects, turns in, or puts away materials. Manages materials in the group during work.

Role Card #5

Time Keeper:
Keeps track of time and reminds groups how much time is left.

Role Card #6

Checker:
Checks for accuracy and clarity of thinking during discussions. May also check written work and keeps track of group point scores.

Round Table

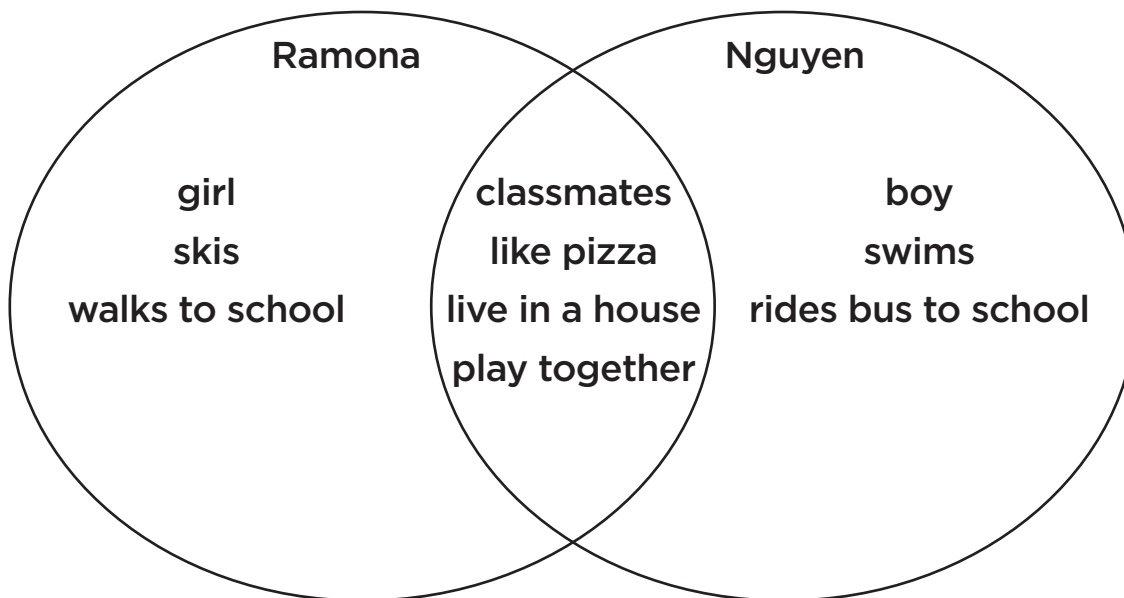
Round table can be used for brainstorming, reviewing, or practicing while also serving as a team builder. Students sit in teams of 3 or more, with one piece of paper and one pencil. The teacher asks a question which has multiple answers. Students take turns writing one answer on the paper, then passing the paper and pencil clockwise to the next person. When time is called, teams with the most correct answers are recognized. Teams reflect on their strategies and consider ways they could improve.

Three-Step Interview

This involves structured group activity with students. Using interviews/listening techniques that have been modeled; one student interviews another about an announced topic. Once time is up, students switch roles as interviewer and interviewee. Pairs then join to form groups of four. Students take turns introducing their pair partners and sharing what the pair partners had to say. This structure can be used as a team builder, and also for opinion questions, predicting, evaluation, sharing book reports, etc.

Venn Diagram

A diagram using circles to represent sets, with the position and overlap of the circles comparing and contrasting the relationships between two given pieces of information.



References and Credits

Photo Credits:

CLOWNFISH

<http://www.photolib.noaa.gov/htmls/reef1412.htm>

CRAB

<http://www.magazine.noaa.gov/stories/mag203.html>

DAMSELFISH

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FINGER CORAL

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FLAT WORM (BANDED /ORANGE RING)

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GOATFISH

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HUMUHUMUNUKUNUKUAPUA‘A

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LOBSTER (SLIPPER LOBSTER)

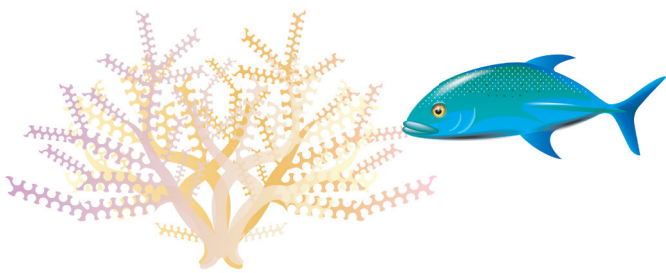
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MILLET SEED

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NEEDLENOSE BUTTERFLYFISH

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NUDIBRANCH (GOLDEN LACE)

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PARROTFISH

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PENCIL URCHIN

<http://www.noanews.noaa.gov/stories2006/s2644.htm>

PUFFERFISH

http://oceanexplorer.noaa.gov/explorations/02sab/logs/aug15/media/puffer_600.jpg

RICE CORAL

http://hawaii.gov/dlnr/dar/coral_liverock.html

(Larger || High Res.) <http://www.noanews.noaa.gov/stories2006/s2644b.htm>

SEA CUCUMBER

<http://www.photolib.noaa.gov/htmls/reef0210.htm>

SEASTAR

<http://www.photolib.noaa.gov/htmls/reef0296.htm>

SHRIMP (HARLEQUIN)

http://www.mauioceancenter.com/images/creatures/harlequin_shrimp.jpg

SNOWFLAKE EEL

NPS photo - Bryan Harry - Waikiki Aquarium

http://www.botany.hawaii.edu/basch/uhnpscesu/htms/npsafish/fish_pops/murean/eel02.htm

SPONGE

<http://www.photolib.noaa.gov/htmls/reef0312.htm>

STAGHORN CORAL

http://www.botany.hawaii.edu/basch/uhnpscesu/htms/NPSAcorl/fish_pops/acropori/coral39.htm

TAKO

http://www.mauioceancenter.com/index.php?id=11&ss=0&page=marine&content=marine_detail&cat=2&CRid=31&limitstart=0

TRUMPET SNAIL

<http://www.photolib.noaa.gov/htmls/reef1119.htm>

TUBEWORMS

<http://www.morning-earth.org/Graphic-E/Biosphere/Bios-PL-BenthicBiomes2.htm>

YELLOW TANG

<http://www.photolib.noaa.gov/htmls/reef0023.htm>

