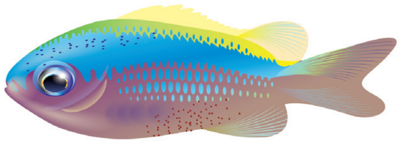
GRADE 3 UNIT 3 OVERVIEW
Coral Reef Habitat



Introduction

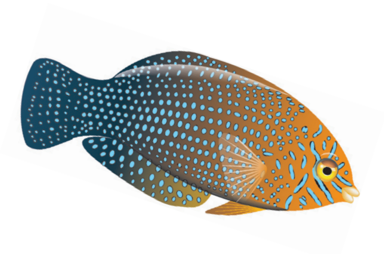
Healthy coral reefs make significant contributions to the well-being of people, animals, and plants in marine and coastal environments. They also provide natural breakwaters protecting coastal land from the erosive power of big waves and storms.

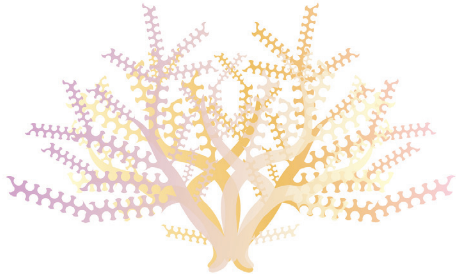
In this unit, students embark on a fact-finding journey taking them under shallow coastal ocean waters to learn about coral reef habitats, structure and function of the coral animals, and the common Hawaiian coral reefs that host unique species of marine plants and organisms.

Coral reef animals have adapted to their habitat, through evolutionary development of body parts and features that address feeding requirements, and help protect them from predators. Learning activities and data analysis investigations engage students in seeking answers to their coral reef questions.

Coral reefs are important environmental and economic resources for people. Population growth is stressing the slow-growing and fragile coral reefs, and contributing to their destruction at alarming rates. Students will learn about the effects of marine debris, water runoff carrying toxic agents, and other pollutants on coral reefs. Another issue is over-fishing to meet increased demand that is quickly depleting fish resources. Also addressed are the potentially catastrophic consequences of worldwide climate change that may threaten reef habitats, coastal areas, and even human life.

In this unit's conclusion, students create products to educate others on the importance of coral reefs and conservation measures that might help curb activities deemed harmful to natural resources and the marine environment.



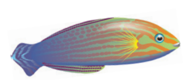


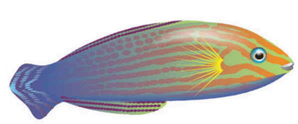
At A Glance

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

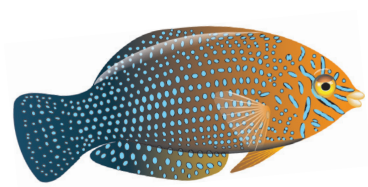
ESSENTIAL QUESTIONS	HCPSIII BENCHMARKS*	LESSON, Brief Summary, Duration
What environmental conditions determine where coral reefs form, and how they are structured for survival? What are the features of the types of corals that build coral reefs in Hawai‘i? What role do coral colonies play in a marine environment?	Science Standard 3: Life and Environmental Sciences: Organisms and the Environment: SC.3.3.1: Describe how plants depend on animals. Science Standard 4: Life and Environmental Sciences: Structure and Function in Organisms: SC.3.4.1: Compare distinct structures of living things that help them to survive. Science Standard 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution: SC.3.5.1: Describe the relationship between structure and function in organisms. Language Arts Standard 4: Writing: LA.3.4.1: Write in a variety of grade-appropriate formats for a variety of purposes and audiences.	**Lesson 1: An Introduction to the Coral Reef Habitat** Students create concept maps to determine the basic needs of organisms for survival. Through a PowerPoint presentation, students are introduced to coral reef habitats, reef zones and types of coral common in Hawai‘i. After the presentation, the class will discuss coral reef characteristics, and what it would be like to live in a coral reef. The lesson wraps up by having the students write a descriptive poem about common coral species found on the reef. Three 45-minute periods

ESSENTIAL QUESTIONS	HCPSIII BENCHMARKS*	LESSON, Brief Summary, Duration
What are the unique structures of coral, and how do they function to help coral survive in the marine environment?	Science Standard 3: Life and Environmental Sciences: Organisms and the Environment: SC.3.3.1: Describe how plants depend on animals. Science Standard 4: Life and Environmental Sciences: Structure and Function in Organisms: SC.3.4.1: Compare distinct structures of living things that help them to survive. Science Standard 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution: SC.3.5.1: Describe the relationship between structure and function in organisms.	**Lesson 2: Coral Structure and Function** This lesson teaches about the unique structures of coral. Students will begin the lesson with a hands-on modeling activity where they will create a coral polyp. This leads the class to begin learning how coral survives in the marine environment. To better understand how corals survive in their habitat, the class will participate in a role-play activity to compare the daytime and nighttime feeding adaptations of a coral colony. Finally, students learn about how coral is adapted to protect itself from natural stresses. Two 45-minute periods





ESSENTIAL QUESTIONS	HCPSIII BENCHMARKS*	LESSON, Brief Summary, Duration
How do human activities on land and in the marine environment impact the health of coral reefs? How can people help to preserve and protect the coral reef habitat?	Science Standard 1: The Scientific Process: SC.3.1.1: Pose a question and develop a hypothesis based on observations. SC.3.1.2: Safely collect and analyze data to answer a question. Science Standard 2: The Scientific Process: SC.3.2.1 Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society. Social Studies Standard 7: Geography: SS.3.7.4 Examine the ways in which people modify the physical environment and the effects of these changes. Language Arts Standard 4: Writing: Conventions and Skills: LA. 3.4.1 Write in a variety of grade appropriate formats for a variety of purposes and audiences. Language Arts Standard 5: Writing: Rhetoric: LA. 3.5.2 Use significant details and relevant information to develop meaning.	**Lesson 3: Human Impact on the Coral Reef** In this lesson students will have a class discussion on the ecological importance of coral reefs and their value to humans. That discussion will lead the class to examine the threats to reefs both by humans and by nature. The students are then broken into small cooperative groups where they will work together to learn about human impacts affecting the health of coral reef habitats. Three 45-minute periods



ESSENTIAL QUESTIONS	HCPSIII BENCHMARKS*	LESSON, Brief Summary, Duration
How can we share what we learned about coral reefs and the human impact on the reef ecosystem? What can each of us do to help protect the reefs?	Science Standard 3: Life and Environmental Sciences: Organisms and the Environment: SC.3.3.1: Describe how plants depend on animals. Science Standard 4: Life and Environmental Sciences: Structure and Function in Organisms: SC.3.4.1: Compare distinct structures of living things that help them to survive. Science Standard 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution: SC.3.5.1: Describe the relationship between structure and function in organisms. Language Arts Standard 4: Writing: Conventions and Skills: LA. 3.4.1 Write in a variety of grade appropriate formats for a variety of purposes and audiences. Language Arts Standard 6: Oral Communication: Conventions and Skills: LA 3.6.2 Give a planned speech to share information with peers. Social Studies Standard 7: Geography: SS.3.7.4 Examine the ways in which people modify the physical environment and the effects of these changes.	**Culminating Lesson: Protecting Our Coral Reefs** Students demonstrate their knowledge of coral reef concepts by sharing their work with an appropriate audience (through posters, stories, or murals.) Student teams will complete a product of their choice to reflect knowledge gained in the unit. The students will choose to either develop a story/mural involving creatures from the coral reef and how they are impacted by human activity or create an educational poster to focus on a specific human impact issue. Three 45-minute periods

* "Hawai'i Content & Performance Standards III Database." Hawai'i Department of Education. June 2007. Department of Education. 17 Dec. 2007

Benchmark Assessment

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.3.1.1		Pose a question and develop a hypothesis based on observations	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Pose a question and develop a hypothesis based on logical inferences and observations	Pose a question and develop a hypothesis based on observations	Pose a question or develop a hypothesis partially based on observations	With assistance, pose a question or develop a hypothesis

Topic		**Scientific Inquiry**	
Benchmark SC.3.1.2		Safely collect and analyze data to answer a question	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Summarize and share analysis of data collected safely to answer a question	Safely collect and analyze data to answer a question	With assistance, safely collect and analyze data	With assistance, safely collect data and attempt to analyze data

Topic		**Science, Technology, and Society**	
Benchmark SC.3.2.1		Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Compare how technologies in various fields have influenced society	Describe ways technologies in fields such as agriculture, information, manufacturing, or communication have influenced society	Identify, with assistance, ways that technologies have influenced society	Recall that technologies have influenced society

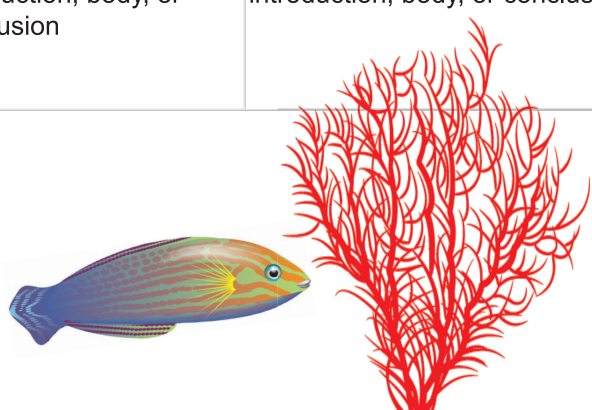
Topic		**Interdependence**	
Benchmark SC.3.3.1		Describe how plants depend on animals	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Classify plants by their dependence on animals.	Describe how plants depend on animals.	Name very few ways in which plants depend on animals.	Recognize that plants depend on animals.

Topic		**Cells, Tissues, Organs, and Organ Systems**	
Benchmark SC.3.4.1		Compare distinct structures of living things that help them to survive	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Group living things by the distinct structures that help them to survive and provide justification for the grouping	Compare distinct structures of living things that help them to survive	Describe a few ways in which distinct structures of living things help them to survive	Name distinct structures of living things that help them to survive

Topic		**Unity and Diversity**	
Benchmark SC.3.5.1		Describe the relationship between structure and function in organisms	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Classify the structures of organisms according to their function	Describe the relationship between structure and function in organisms	Identify the relationship between structure and function in an organism	Recall that structures in organisms are related to the functions they perform

Topic		**Range of Writing**	
Benchmark LA.3.4.1		Write in a variety of grade-appropriate formats for a variety of purposes and audiences, such as: • stories with a beginning, middle, and end and poems with sensory details • short reports on content area topics • pieces related to completing tasks • friendly letters • responses to literature • pieces to reflect on learning and to solve problems	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Insightfully adapt writing to grade- appropriate formats for a variety of purposes and audiences	Adapt writing to grade-appropriate formats for a variety of purposes and audiences	Write with some adaptation to grade-appropriate formats for a variety of purposes and audiences	Write with little adaptation to grade-appropriate formats for a variety of purposes and audiences

Topic		**Design**	
Benchmark LA.3.5.2		Organize information by introducing it, elaborating on it, and drawing a conclusion about it	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Organize information in a highly effective way by smoothly introducing it, elaborating on it, and drawing a conclusion about it	Organize information by introducing it, elaborating on it, and drawing a conclusion about it	Partially organize information with a limited introduction, body, or conclusion	Ineffectively organize information with an unclear introduction, body, or conclusion



Topic		**Discussion and Presentation**	
Benchmark LA.3.6.2		Give a planned speech to share information with peers	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Give a planned speech to share information with peers, in a highly effective way	Give a planned speech to share information with peers	Give a speech that shows some planning but shares limited information with peers	Give a speech that shows little planning and does not share information with peers

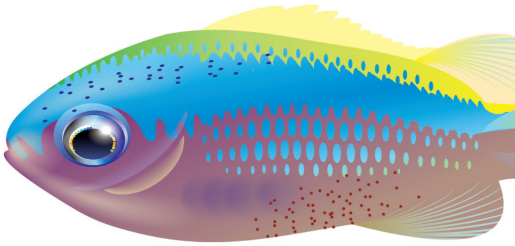
Topic		**Environment and Society**	
Benchmark SS.3.7.4		Examine the ways in which people modify the physical environment and the effects of these changes	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Examine the ways in which people modify the physical environment, and evaluate the effects of these changes.	Examine the ways in which people modify the physical environment, and explain the effects of these changes.	Examine the ways in which people modify the physical environment, or the effects of these changes.	Ineffectively examine the ways in which people modify the physical environment, or the effects of these changes.

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.)

** "Hawai‘i Content & Performance Standards III Database." Hawai‘i Department of Education. June 2007. Department of Education. 17 Dec. 2007.*



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 the 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] (Lessons 1 and 2)

There are three major differences between hard and soft corals: 1) their arrangement and number of tentacles around the mouth 2) their association with symbiotic algae called **zooxanthellae** and 3) the presence and/or composition of their skeletons. Soft corals are often referred to as **octocorals** due to the presence of eight distinct tentacles surrounding the mouth of each individual **polyp**. They 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 zooxanthellae, but do not rely on the algae as a primary source of food energy.

Most soft corals secrete flexible skeletons made from a protein called **gorgonin**, while others secrete discrete amounts of **calcite** (a form of calcium-based mineral) to form **sclerites,** 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 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 around the 1970's 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 only 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.

What is the chemical composition of a coral reef? How does a coral reef form?[2] (Lessons 1 and 2)

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.

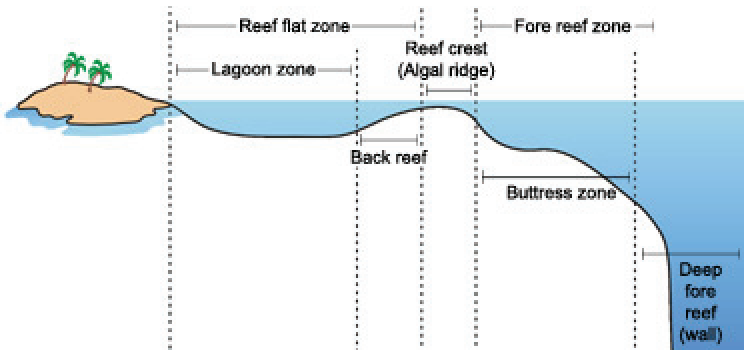
What are the different coral reef zones and what are the physical characteristics of each?[1]

(Lesson 1)

<u>Reef Crest Zone:</u>

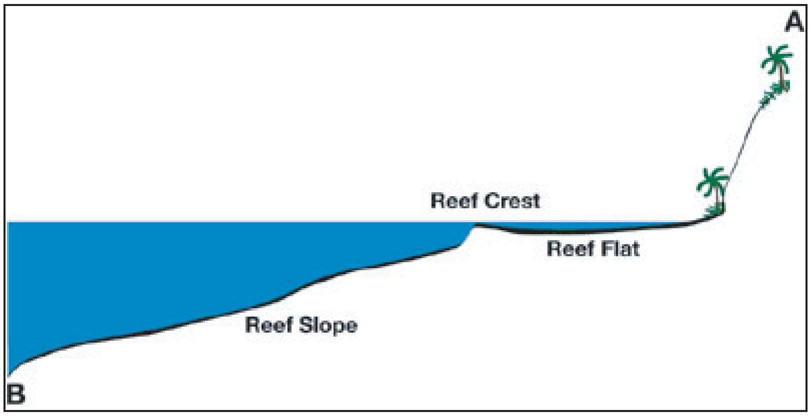
The reef crest zone is the highest (most shallow) part of the reef, and lies between the shoreward, protected back reef zone and the outer fore reef zone. This zone is characterized by a relatively uniform bottom topography made up of coral sand and loose coral rubble and exists from a depth of approximately 0–5 meters. Shallow growing corals may be exposed during extreme low tides. The wave action in the reef crest zone is medium to high, and light penetration is also high. The sea surface temperature can be variable in this zone and can be influenced by day-to-day weather conditions. For example, on a cloudless day, the sun’s intensity can warm the water in this shallow zone more so than if clouds were present. Winds also affect the temperature; on windy days, the water cools faster than on days when only light breezes are blowing. Sediments can become suspended in the water column because of wave action and land influences, affecting the clarity of the water in the reef bench zone. The dominant corals present include the massive lobe coral that can tolerate the higher energy parts of the reef. Below the immediate shallows, an assortment of Hawaiian corals thrive in this zone, including the finger coral, cauliflower coral, mushroom coral, lace coral, and rice coral.

Photo from: http://www.coral-reef-info.com/reef-crest-zone.html



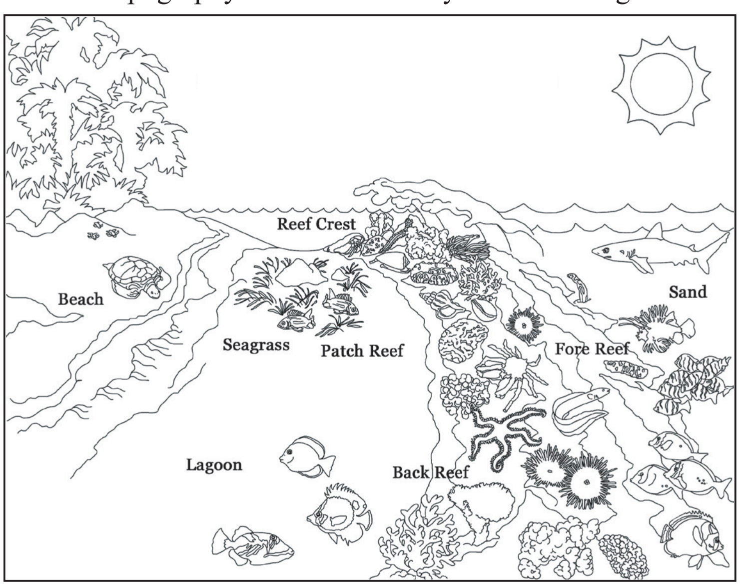
Fore Reef Zone:

The fore reef zone (often called the "reef front") begins at the seaward base of the reef crest. The bottom topography characteristic of the reef slope zone is a gentle sloping bottom with fine grain sand, sediments, and coral rubble interspersed between large colonies of rice coral and finger coral to a depth of 30 meters. The wave action is low to absent, and the light penetration is minimally reduced because of the depth at which this zone resides. The temperature in this zone is more uniform but because of the light reduction, it is common to see large coral colonies in this zone competing for open access to light. Suspended sediments tend to rest here because of the lack of wave action; the water clarity is generally better than in the reef crest zone. The finger coral dominates this part of the reef. However, most of the other coral types previously described can also be found here. (Except for lobe coral, the reef gets out-competed by finger coral because of differences in their respective growth rates.)



Back Reef Zone:

The back reef zone (also commonly called the lagoon) of a coral reef lies immediately shoreward of the innermost margin of the reef crest zone, and extends all the way to the shore. The back reef zone has significantly less coral cover, and the bottom topography consists of mostly sand with large amounts of coral rubble to a depth of 40 meters. Wave action is almost absent in all but the harshest swells and weather, but deeper currents can exist. Light penetration is also reduced and the temperature tends to be uniform. In harsh weather or during big swells, the sandy bottom can become churned up, reducing water clarity. The sandy bottom is not the best place for corals to settle; small colonies of lobe and lace coral are found here. Other invertebrates, like sea cucumbers, dominate the sandy bottoms.



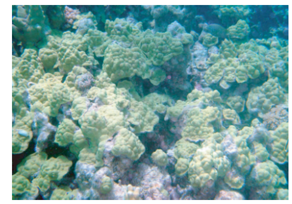
Because of their young geological age, the eight main Hawaiian Islands generally lack barrier reefs that shelter protected lagoons and give rise to the typical reef flat, reef crest, reef slope nomenclature of reef systems. *Kāneʻohe Bay* on the island of *Oʻahu* is the only local example of these reef types. The geologically older Northwestern Hawaiian Islands (now the *Papahānaumokuākea* Marine National Monument), on the other hand, have many barrier reefs, and the reef systems that exist there are more characteristic of reef systems around the world. The three reef zones described above reflect more local geological reef systems typified by the main Hawaiian Islands.

For more information see: http://www.marinebio.net/marinescience/04benthon/crzone.htm and http://www.marinebio.net/marinescience/04benthon/crform.htm

What are different types of stony corals that build reefs in Hawai‘i, and how do the structures of each type of coral allow it to survive in the coral reef environment?[2] (Lesson 1)

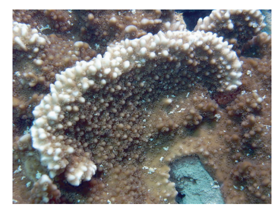
Common hard corals found in Hawai‘i include:

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 where wave action is mild and light penetration is sufficient. These corals 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, it can withstand high wave action and predominates in the reef bench zone where the faster growing, out-competing finger coral cannot grow.

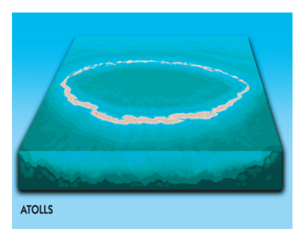
Cauliflower coral (*Pocillopora meandrina*):
This coral has sturdy, thick, flat-leafed branches and grows in small, discreet tufted colonies. It is most common in high-energy wave areas, but can also be found in all three reef zones.



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 more information see: http://www.coralreefnetwork.com/marlife/corals/corals.htm

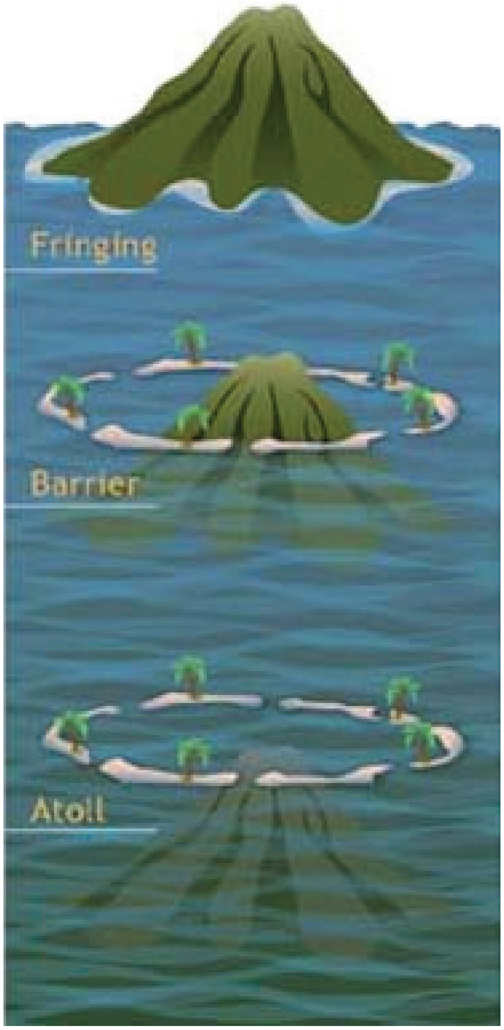
What types of reef formations exist, and how do they change over time?[3] (Lesson 3)



There are four major types of reef formations that develop around islands: fringing reefs, patch reefs, barrier reefs and atolls. **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.

Image from: http://sanctuaries.noaa.gov/science/condition/fbnms/images/history4.jpg



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

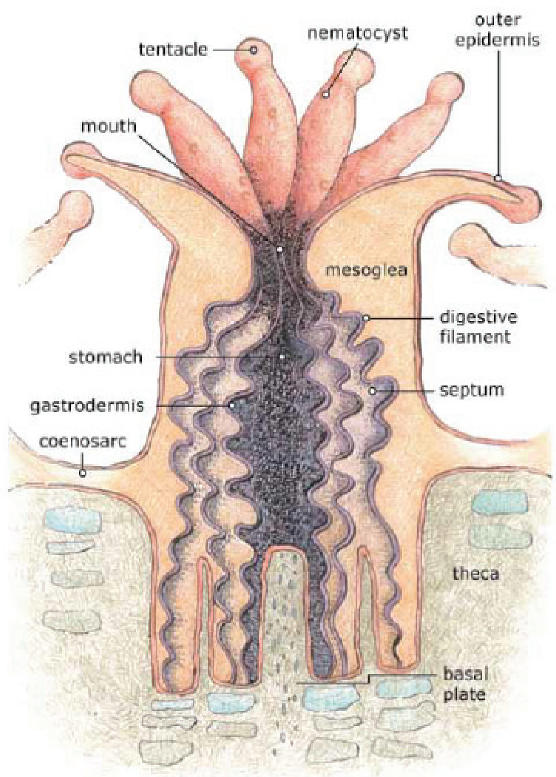
The relative ages of islands can be compared based on the type of reef structure surrounding the island. Younger islands tend to have fringing reef structures, or barrier reef structures, and are usually high islands because of the amount of volcanic landmass still present above the surface. Older islands 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
http://www.starfish.ch/reef/reef.html
http://www.coris.noaa.gov/about/what_are/

What is a coral? Describe in simple terms, the structure, and main parts of a coral and how they feed.[3] (Lesson 2)

Stony or reef-building corals are simple **invertebrate** animals. The corals that comprise coral reefs are **colonial** animals that are composed of hundreds and hundreds of individual **polyps**. Each coral polyp has a mouth surrounded by tentacles that leads to a stomach. Coral polyps living in a colony are connected to each other through their stomachs by a specialized tissue layer termed **coenocarc**. The tentacles capture smaller animals and plants that are floating in the water column and bring the food to the mouth to be digested. The tentacles contain special stinging cells called **cnidocytes**. These special cells release stinging structures called **nematocysts** that aid in the animals' defense against predators as well as their own capture of food organisms. Reef building corals also house single-celled marine algae called **zooxanthellae** in their tissues. These small plants use sunlight and the animal's waste products in photosynthesis to make food for the coral. This is the main reason why coral reefs are only found in shallow, warm, sunny parts of the ocean, as the zooxanthellae need light in order to photosynthesize. The relationship between the zooxanthellae and the coral is called a mutualism. It is a symbiotic relationship where both organisms benefit. The zooxanthellae live within the coral and receive nutrients (especially nitrogen) from the coral, while the coral receives food that the zooxanthellae make through photosynthesis.

For more information see: http://www.coris.noaa.gov/about/what_are



How do corals obtain food?[4] (Lessons 1 and 2)

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 the unique features of organisms that enable them to survive in the different living spaces of the coral reef habitat?[4] (Lesson 2)

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 butterfly fish, *lauwiliwilinukunukuoiʻoi*).

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*) *wekeʻā*:
These fish have their mouths positioned on the bottom of their snouts, and they possess two barbels 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 butterfly fish (*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.

How do human activities on land and in the marine environment impact the health of coral reefs?[5] (Lesson 3)

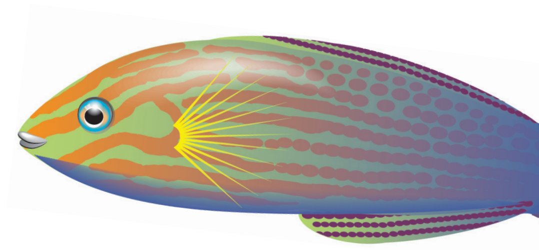
Human population growth and urban development cause **erosion**, **fertilizers,** and **sewage** to be carried onto the reef by storm water, streams, and rivers, resulting in damage to the reef. An increase of **nutrients** within the reef environment is followed by increase of algae, which may smother corals. This was very apparent in *Kāneʻohe Bay,* where up until the 1980's, sewage was discharged directly into the bay. This resulted in excess nutrients in the ecosystems, causing rapid overgrowth of algae on the reefs, killing corals, and severely disrupting the ecosystem. Now that the sewage outfalls are offshore, *Kāneʻohe Bay* is slowly recovering.

Turbidity from these nutrient and fertilizer sources also reduces the amount of sunlight reaching the corals, making it harder for them to grow. Along with human population growth, the over-harvesting of resources, like fish and other reef organisms, for food and the aquarium trade, allows some organisms to dominate reefs that once were kept in check by large reef fish populations. This is throwing off the natural checks and balances that the reef maintains to keep healthy. Careless divers and snorkelers may harm the corals and critters by touching the reefs and sensitive coral polyps, and boats can damage the reef by dragging anchors or grounding on the reefs.

Corals are also sensitive to changes in water temperature, and are able to survive only within very narrow temperature ranges. Global climate change is causing our oceans to warm, making it harder for corals to survive, and is thought to be a major cause of harmful **coral bleaching.** For more information see: http://www.coris.noaa.gov/about/hazards

Science Background for the Teacher Glossary

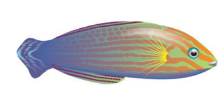
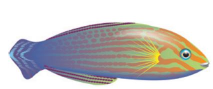
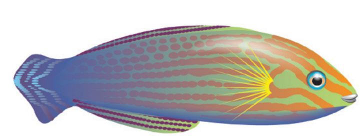
aragonite: a form of calcium carbonate mineral.
asexual reproduction: when an organism produces a clone of itself; does not involve the fusion of sex cells or genetic material.
atolls: ringed coral reef island enclosing a lagoon.
barrier reef: a coral reef structure that is parallel to a land mass and encloses a lagoon.
bottom topography: the shape and physical features of the ocean floor.
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.
calyx: the cup-like calcium carbonate skeleton of stony corals in which a coral polyp sits; secreted by the lower portion of a coral polyp.
carnivore: organism that eats other animals.
clones: genetically identical organisms of the same species.
cnidocytes: specialized structures found in coral tentacles that release nematocysts for defense against predators.
colonial: many individual animals living among or connected to each other.
coral bleaching: the process in which the *zooxanthellae* living inside coral tissues leave the coral, making the coral colony appear white in color; if the algae do not return to the coral, the coral cannot get enough food on its own and dies.
erosion: the wearing away of rock, soil, and sediments by wind and rain.
fertilizers: nutrients that aid in plant growth.
fission: type of asexual reproduction in which an organism splits itself in half to produce two genetically identical individuals**.**
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.
herbivore: organism that eats plants and/or algae.
hermatypic: refers symbiosis with zooxanthellae.
invertebrate: animals without backbones such as insects, worms, and coral.
light penetration: the amount of sunlight that travels through the water.
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.
nematocysts: specialized stinging cells found in the tentacles of corals that are used for defense.



nutrients: the compounds that plants use during photosynthesis to grow.
octocorals: soft corals that do not build reefs.
omnivore: organism that eats both plants and animals.
patch reefs: isolated coral reef structures that can vary in size and are usually found inside lagoons.
photosynthesis: the process by which green plants, algae, and some bacteria use energy from sunlight to make food compounds.
planktivores: organisms that feed on plankton in the water column.
plankton: plants and animals that live in the water column and are transported by currents.
polyp: a non-swimming, sessile, or 'grounded' single individual coral animal.
predators: animals that capture, or prey on other animals for food.
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.
sclerites: semi-fused calcite fragments found in soft corals.
septa: walls that extend into each calyx.
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.
suspended sediments: the sand, soil, and other particles in the water column that can compromise the clarity of the water and affect the amount of penetrating sunlight.
symbiosis: a relationship between different species where one (commensalism), or both (mutualism), of the organisms benefit from the presence of the other.
turbidity: the cloudiness of the water caused by particles and pollutants.
vertebrate: animals with backbones such as fish, mammals, and birds.
wave action: the intensity and frequency of waves.
zonation: the distribution of plants and animals along an environmental gradient, i.e., tidal and/or depth gradient.
zooxanthellae: single-celled algae that live in a symbiotic relationship with corals and other invertebrate. animals on the reef, providing corals with food through photosynthesis.

Science Background for the Teacher- Bibliography

[1-6] ***Science background information condensed and/or compiled from the following sources:***
1: Andersen, G. (2003). Coral reef Zonation. Retrieved March 15, 2007 from http://www.marinebio.net/marinescience/04benthon/crzone.htm
2: Hawai'i Coral Reef Network. (2005). Corals of Hawai'i. Retrieved March 15, 2007 from http://www.coralreefnetwork.com/marlife/corals/corals.htm
Hoover, J. P. (1998). *Hawai'i's sea creatures: A guide to Hawai'i's marine invertebrates.* Honolulu, HI: Mutual Publishing.
3: NOAA. (2007). What are corals and coral reefs? Retrieved March 15, 2007 from http://www.coris.noaa.gov/about/what_are/
Hoover, J. P. (1998). *Hawai'i's sea creatures: A guide to Hawai'i's marine invertebrates.* Honolulu, HI: Mutual Publishing.
Kaplan, E. H. (1982). *A field guide to coral reefs of the Caribbean and Florida.* Boston: Houghtin Mifflin Company.
4: Helfman, G. S., Collette, B. B., & Facey, D. E. (1999). *The diversity of fishes* (3rd ed.). Malden, MA: Blackwell Science, Inc.
Hoover, J. P. (2003). *Hawai'i's fishes: A guide for snorkelers, divers, and aquarists* (9th ed.). Honolulu, HI: Mutual Publishing.
Hoover, J. P. (1998). *Hawai'i's sea creatures: A guide to Hawai'i's marine invertebrates.* Honolulu, HI: Mutual Publishing.
New World Publications (1999). What do fish eat? Retrieved March 15, 2007 from http://www.fishid.com/learnctr/fisheat.htm
5: NOAA. (2007). Hazards to coral reefs. Retrieved March 15, 2007 from http://www.coris.noaa.gov/about/hazards/

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:

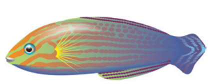
Outreach Unit
NOAA Office of Public and Constituent Affairs
1305 East West Highway #1W514
Silver Spring, MD 20910
Phone: (301) 713-1208
Email: NOAA-OUTREACH@noaa.gov
http://www.education.noaa.gov/

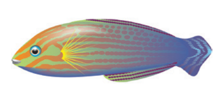
Resources:

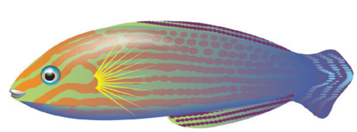
- **A wide variety of Coral Reef themed educational resources can be found at http://coralreef.noaa.gov/, http://coris.noaa.gov/ and http://coralreefwatch.noaa.gov/satellite/education/index.html**

- **Adaptations from the Depths – Flower Garden Banks National Marine Sanctuary (grades K-4)**

- **"Discover Coral Reefs" activity book developed in collaboration with NOAA and Project WET**







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.
   - 5f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e. it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

6. The ocean and humans are inextricably interconnected.
   - 6c. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
   - 6d. Much of the world's population lives in coastal areas.
   - 6e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
   - 6g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Lesson 1: 5a. 5d. 5e. 5f.
Lesson 2: 5c. 5d. 5e. 5f. 6e.
Lesson 3: 5d. 5f. 6c. 6d. 6e. 6g.
Culminating: 5d. 6e. 6g. and any combination of the above

CLIMATE LITERACY ESSENTIAL PRINCIPLES

3. Life on Earth depends on, is shaped by, and affects climate.
   - 3a. Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight. Organisms exposed to climate conditions outside their normal range must adapt or migrate, or they will perish.

6. Human activities are impacting the climate system.
   - 6a. The overwhelming consensus of scientific studies on climate indicates that most of the observed increase in global average temperatures since the latter part of the 20th century is very likely due to human activities, primarily from increases in greenhouse gas concentrations resulting from the burning of fossil fuels.

6c. Human activities have affected the land, oceans, and atmosphere, and these changes have altered global climate patterns. Burning fossil fuels, releasing chemicals into the atmosphere, reducing the amount of forest cover, and rapid expansion of farming, development, and industrial activities are releasing carbon dioxide into the atmosphere and changing the balance of the climate system.

7. Climate change will have consequences for the Earth system and human lives.

7a. Melting of ice sheets and glaciers, combined with the thermal expansion of seawater as the oceans warm, is causing sea levels to rise. Seawater is beginning to move onto low-lying land and to contaminate coastal fresh water sources and beginning to submerge coastal facilities and barrier islands. Sea-level rise increases the risk of damage to homes and buildings from storm surges such as those that accompany hurricanes.

7d. The chemistry of ocean water is changed by absorption of carbon dioxide from the atmosphere. Increasing carbon dioxide levels in the atmosphere is causing ocean water to become more acidic, threatening the survival of shell-building marine species and the entire food web of which they are a part.

Lessons 1 & 2: 3a
Lesson 3: 3a. 6a. 6c. 7a. 7d.
Culminating: 3a. and any combination of the above

NOAA Marine Science Career - Case Studies

Kathy Chaston, PhD

Coral and Coastal Management Specialist

NOAA Coral Reef Conservation Program

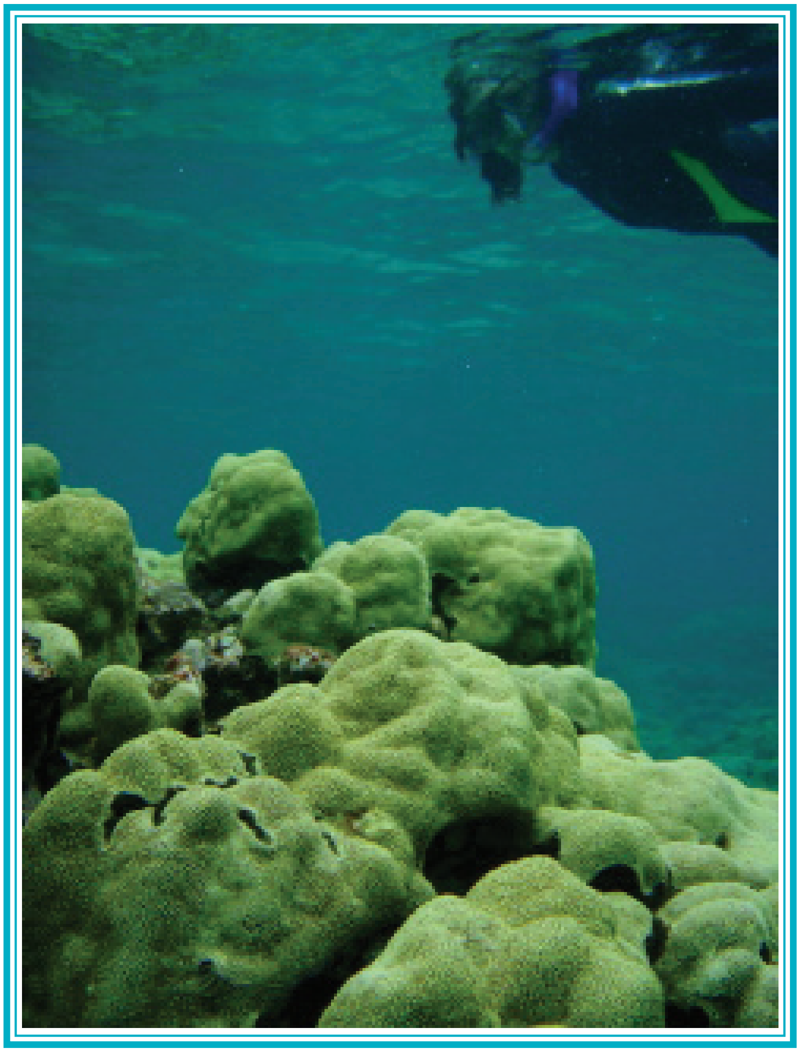
Protecting corals! Let's meet Dr. Kathy Chaston who is going to tell us about her job as a coral and coastal management specialist. Kathy currently works for NOAA's Coral Reef Conservation Program.

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, which 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 Hawai‘i.



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 Hawai‘i. 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 KNOW?	WHAT DO I WANT TO KNOW? *or* WHAT DO I WANT TO SOLVE?	WHAT HAVE I LEARNED?
•		•

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 aide 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

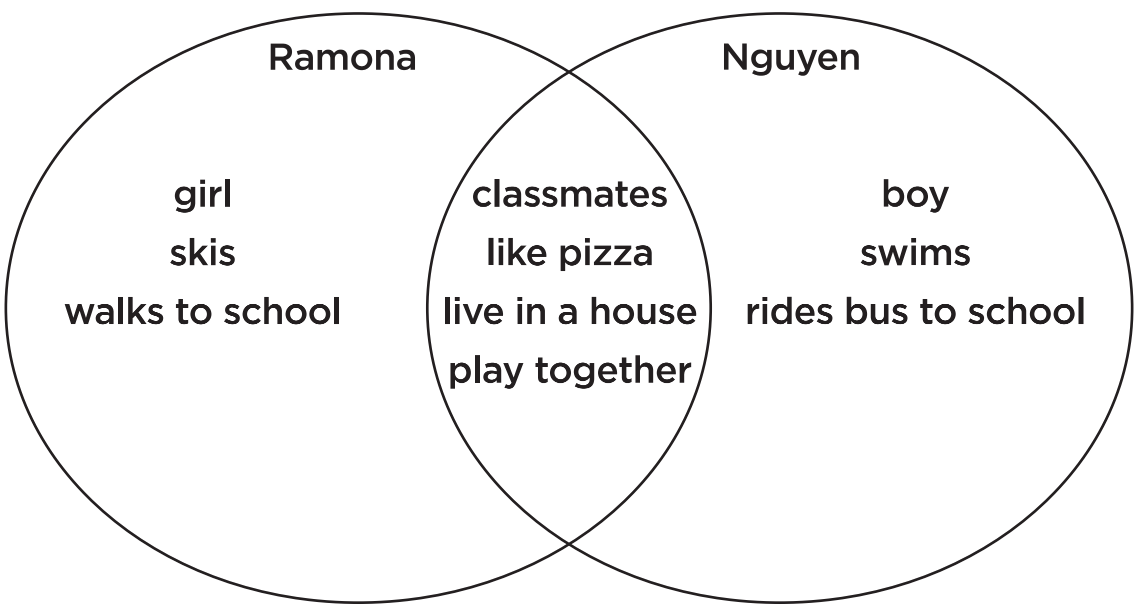
Round table can be used for brainstorming, reviewing, or practicing while also serving as a team builder. Students sit in teams of 3 or more, with one piece of paper and one pencil. The teacher asks a question which has multiple answers. Students take turns writing one answer on the paper, then passing 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

Brainard, R. (2006). *About Creefs*. Retrieved January 22, 2007 from Census of Coral Reefs Website: http://www.creefs.org/aboutCReefs/ .

Brown, Ruth et al. *Coral Forest Teacher's Guide*. San Francisco, CA: Coral Forest, 1996. Coral Reef Zones Color Page.

Coral Reef Center: Math. (2006). Comparing Animal Characteristics and Animals Seen in the Coral Reef. Retrieved January 10, 2007 from ABC Teach Website: http://abcteach.com/free.c.cr_math_understandgraphs.pdf.

Coral: Animal, Mineral, or Vegetable? (2004). Retrieved December 3, 2006 from Ocean World Website: http://oceanworld.tamu.edu/students/coral/coral1.htm .

D. Bryant, et al. (1998). Reefs at Risk: A map-based indicator of threats to the world's coral reefs. Retrieved January 23, 2007 from World Resources Institute Website: http://marine.wri.org/pubs_description.cfm?PubID=2901 .

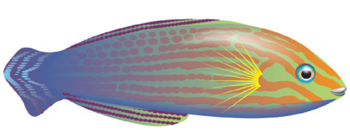
Environmental Controls on Reef Development. Retrieved February 7, 2007 from University of Hawai'i Website: http://www.hawaii.edu/ssri/hcri/files/education/edu-about-01.pdf

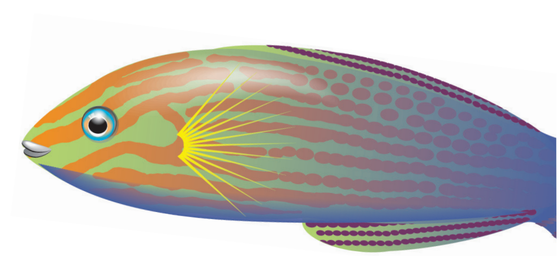
Fletcher, C., et al. (2002). *Coral Growth and the Effect of Human Activitie*s:

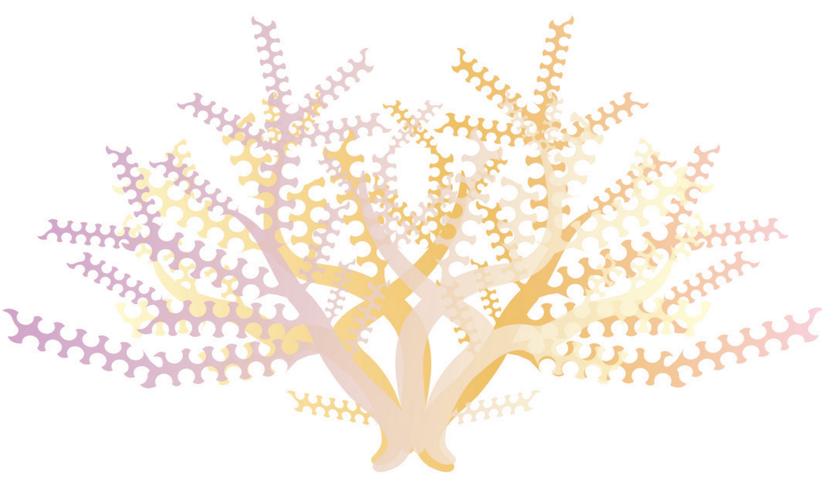
Gulko, D. (1998). *Hawaiian Coral Reef Ecology*. Honolulu, HI: Mutual Publishing.

Gulko, D. (1998). *In Human Uses of Corals & Coral Reefs, Hawaiian Coral Reef Ecology* (pp. 207–9). Honolulu, HI: Mutual Publishing.

Hammond, K. (2006). *Reefs in Trouble*. Retrieved January 22, 2007 from Mother Jones Website: http://www.motherjones.com/news/special_reports/coral_reef/science.html







Hoover, J.P. (1998). *Hawai'i's Sea Creatures: A Guide to Hawai'i's Marine Invertebrates*. Honolulu, HI: Mutual Publishing.

Hoover, J.P. (2003). *Hawai'i's Fishes: A Guide for Snorkelers, Divers, and Aquarists.* Honolulu, HI: Mutual Publishing.

Mitchell, K. (2006). *Poetry for Kids.* Retrieved January 12, 2007 from Mrs. Mitchell's Virtual School Website: http://www.kathimitchell.com/Poemtypes.html.

National Marine Sanctuary Foundation. (2007). *Northwestern Hawaiian Islands Marine National Monument.* Retrieved February 4, 2007 from Encyclopedia of the Sanctuary Website: http://www8.nos.noaa.gov/onms/park/Parks/?pID=12 .

NOAA Oceans and Coasts. (2005). *Nonpoint Source Pollution*. Retrieved January 24, 2007, from NOAA's National Ocean Service Website: http://oceanservice.noaa.gov/education/kits/pollution/04nonpointsource.html

NOAA's National Ocean Service Education Discovery Kits. (2004). *How Do Stony Corals Grow? What Forms Do They Take?* Retrieved January 9, 2007 from http://www.nos.noaa.gov/education/kits/corals/coral03_growth.html.

SeaWorld/Busch Gardens Animal Information Database. (2002). *Habitat and Distribution*. Retrieved January 10, 2007 from http://swbg-animals.com/Infobooks/Coral/habdiscr.html.

Shah, A. (2004). Coral Reefs: *Ecosystems of Environmental and Human Value*. Retrieved January 22, 2007 from Global Issues Website: http://www.globalissues.org/EnvIssues/Biodiversity/CoralReefs.asp.

Shedd Educational Adventures. (2007). Dining Out in the Coral City from Shedd Acquarium Website: http://www.sheddaquarium.org/SEA/lessons_plans.cfm?id=41.

Teachnet.Com. (n.d.). *Traditional Play Dough*. Retrieved December 3, 2006 from Teachnet Web site: http://www.teachnet.com/lesson/art/playdoughrecipes/traditional.html.

Tissot, B. (2005). *The Hawaiian Reef Ecosystem*. Retrieved January 30, 2007 from Hawai'i Coral Reef Network Website: http://www.coralreefnetwork.com/reefs/ecology.ecology.htm.

Tissot, B.N. (2005). *Overview of Ecology of Coral Reefs in Hawai'i.* Retrieved January 5, 2007 from Hawai'i Coral Reef Network Website: http://www.coralreefnetwork.com/reefs/ecology/default.htm .

WebRing Inc. (2007). *Old McDonald Had a Farm* retrieved January 9, 2007 from Becky's Guiding Resource Centre http://dragon.sleepdeprived.ca/songbook/songbook_index.htm

Webster, J.R., et al. (2004). *Hawai'i's drowned coral reefs-victims of sudden climate change?* Retrieved January 23, 2007 from http://www.mbari.org/news/homepage/2004/reefs-webster.html.