GRADE 5 UNIT 5 OVERVIEW
Living Resources of the Ocean

Introduction

Living marine resources are vital components of human life. In fact, most living organisms caught in oceans are harvested for human consumption, while other marine materials are used to make products ranging from sponges to cosmetics. It is important to manage how we take and use the living resources of the ocean to ensure populations of these vital stocks remain at harvestable levels. Although estimated seafood consumption numbers are low in comparison to other foods consumed worldwide, their nutritional value is substantially higher. Most major fisheries occur in shallow, near shore waters, while larger or migratory species are more commonly found in open-ocean fisheries. Marine food chains and webs are complex and fragile. Over-fishing and water pollution can cause disruptions in these food chains resulting in reductions in ocean fish stocks.

In this unit, students are initially introduced to seafood sold in Hawai‘i. They consult newspaper seafood advertisements to define and identify the different types of seafood consumed by islanders.

Students review the role of decomposers in marine ecosystems, and construct diagrams linking decomposers to producers and consumers in food chains and webs, noting that decomposers help recycle the energy that is available in ecosystems. Students investigate what happens to the cycle of matter and flow of energy when humans are introduced into the food chain. They also consult United States Department of Agriculture’s (USDA) dietary guidelines to investigate the benefits and potential hazards of eating seafood.

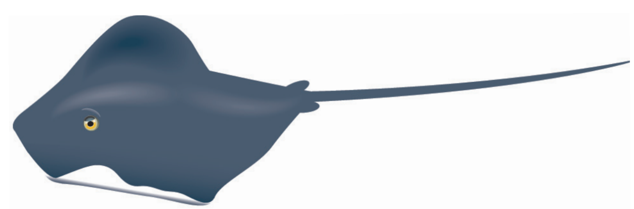
The unit wraps up with a student introduction to fisheries. They will learn that the National Oceanic and Atmospheric Administration (NOAA) is the organization that determines and manages fisheries. One of the ways NOAA manages fisheries is by putting rules, laws or methods in place. The students will participate in a hands-on activity that shows them how the “capture and recapture” method works.

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	HCPS III BENCHMARKS	LESSON, *Brief Summary,* Duration
What are the roles of the producers, consumers, and decomposers in a marine ecosystem? How does energy flow and matter cycle in a marine environment? What kinds of marine organisms do humans consume? How does human consumption impact the population of marine organisms in food webs and food chains?	Science Strand 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 Strand 3: Life and Environmental Sciences: SC. 5.3.1 Describe the flow 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 cycles of matter. Language Arts Strand 1: Reading Conventions and Skills: LA.5.1.1 Use new grade-appropriate vocabulary learned through reading print and online resources and word study, including meanings of roots, affixes, word origins.	**Lesson 1: Marine Food Chains and Webs** The students get a brief review of food chain and food webs of living marine organisms. They develop vocabulary and assemble a list of the marine organisms that are used as food and are sold in stores in Hawaii using advertisements from local newspapers. Then, students fill in the *Marine Organism Identification* Worksheet by looking up the definitions of and classifying their seafood lists as finfish, shellfish (mollusk or crustacean), and other vertebrates, invertebrates. They develop an understanding of the different categories of marine organisms and which marine organisms are harvested as a food source by us. They discuss the criteria of a marine food web and construct a seafood web using the marine organism lists that they have collected. They discuss and collect information on marine organisms to complete a complex marine food web. Three 45-minute periods

ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	**LESSON,** *Brief Summary,* Duration
How does an energy pyramid help us understand the flow of energy in food chains and webs? How do we calculate the energy flow through the marine food web?	Science Strand 2: The Scientific Process: SC.5.2.1Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world. Science Strand 3: Life and Environmental Sciences: SC. 5.3.1 Describe the flow 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 cycles of matter. Math Strand 1: Numbers and Operations: MA 5.1.1 – Represent percent and ratio using pictures and objects.	**Lesson 2: An Ocean of Energy** Students are introduced to an energy pyramid as a different graphic model to show the energy relationships among producers, consumers, and decomposers. Students construct an energy pyramid using information presented in the PowerPoint *An Ocean of Food Chains and Food Webs* and their marine seafood web. Two 45-minute periods



ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	**LESSON,** *Brief Summary,* Duration
How does the human consumption of seafood impact the marine food chain? Is the consumption of seafood always a healthy choice?	Science Standard 1:The Scientific Process: SC.5.1.2 Formulate and defend conclusions based on evidence. Science Strand 3: Life and Environmental Sciences: SC.5.3.2 - Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter. Health Strand 1: Core Concepts: HE. 3-5.1.3 Explain the importance of a healthy diet as part of a healthy lifestyle.	**Lesson 3: Seafood and Human Health** In this lesson, students are first asked whether humans are part of food chains, then they modify a food chain/web and work on an energy pyramid to describe the cycle of matter and the flow of energy through a graphic model to show where humans fit into these models. Students then learn from a PowerPoint slide about the USDA dietary guidelines that fish and shellfish are healthy foods, but that some seafood should be avoided because of mercury content. Images in the slide show illustrate the process of bioaccumulation. Two 45-minute periods
What are the current methods for gathering food from the sea? How can humans manage marine resources and assure their sustainability for the future? How has technology improved our ability to harvest food from the sea?	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. Math Standard 10: Patterns, Functions and Algebra: Math MA 5.10.2 Model problem situations with objects or manipulatives and use representations (e.g., graphs, tables, equations) to draw conclusions.	**Lesson 4: Sustaining Our Ocean Resources** This lesson gives students a basic introduction to fisheries, why they are important, and the various methods used to maintain sustainable levels of various marine organisms. Students then have an opportunity to use the capture-recapture model to investigate how scientists monitor the size and number of a marine population and monitor whether fish populations are decreasing. Two 45-minute periods

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

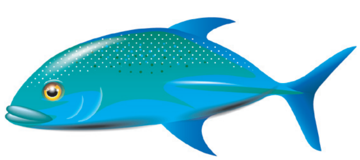
Benchmark Rubric

I. HCPS III Benchmarks*

Below is a general Benchmark Rubric. Within each lesson, there are other assessment tools and additional rubrics specific to the performance tasks within each lesson.

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

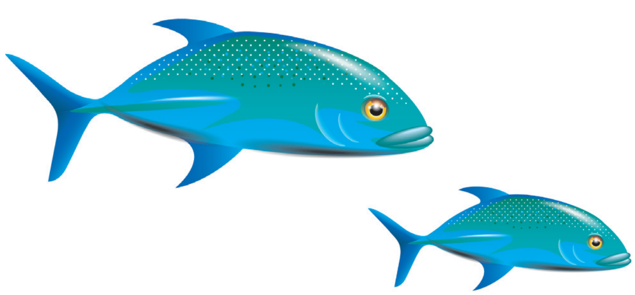
Topic		**Cycles of Matter and Energy**	
Benchmark SC.5.3.1		Describe the cycle of energy among producers, consumers, and decomposers	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Explain and give detailed examples of the cycle of energy among producers, consumers, and decomposers	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

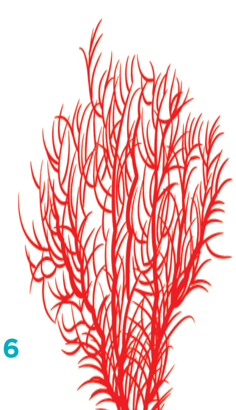


Topic		Interdependence	
Benchmark SC.5.3.2		Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Explain and give examples of how specific relationships 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

Topic		Vocabulary and Concept Development	
Benchmark LA.5.1.1		Use new grade-appropriate vocabulary learned through reading print and online resources and word study, including meanings of roots, affixes, word origins	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Use new grade-appropriate vocabulary, with fluency, precision, and accuracy	Use new grade-appropriate vocabulary, with minimal difficulty and no significant errors	Use new grade-appropriate vocabulary, with difficulty and a few significant and/or many minor errors	Use new grade-appropriate vocabulary, with great difficulty and many significant errors or rarely use new vocabulary

Topic		Healthy Eating and Physical Activity	
Benchmark HE.3-5.1.3		Explain the importance of a healthy diet as part of a healthy lifestyle	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Explain, in great detail, the importance of a healthy diet as part of a healthy lifestyle	Explain, in detail, the importance of a healthy diet as part of a healthy lifestyle	Explain, in some detail, the importance of a healthy diet as part of a healthy lifestyle	Explain, in minimal detail, the importance of a healthy diet as part of a healthy lifestyle





Topic		Numbers and Number Systems	
Benchmark MA.5.1.1		Represent percent and ratio using pictures or objects	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Represent percent and ratio using pictures or objects, with accuracy	Represent percent and ratio using pictures or objects, with no significant errors	Represent percent and ratio using pictures or objects, with a few significant errors	Represent percent and ratio using pictures or objects, with many significant errors

Topic		Numeric and Algebraic Representations	
Benchmark MA.5.10.2		Model problem situations with objects or manipulatives and use representations (e.g., graphs, tables, equations) to draw conclusions	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Model problem situations with objects or manipulatives and use representations to draw conclusions, with accuracy	Model problem situations with objects or manipulatives and use representations to draw conclusions, with no significant errors	Model problem situations with objects or manipulatives and use representations to draw conclusions, with a few significant errors	Model problem situations with objects or manipulatives and use representations to draw conclusions, with many significant errors

II. General Learner Outcomes*

A list of the Hawai‘i Department of Education’s General Learner Outcomes (GLOs) follows. 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.).

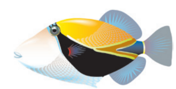
** “Hawaii Content & Performance Standards III Database.” Hawaii Department of Education. June 2007. Department of Education. 17 Dec. 2007.*

Science Background for the Teacher

Note: Bolded words 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 are living marine resources?[1] (Lesson 1)

The world's oceans are composed of both physical and biological components. The physical components include all of the non-living structures and processes, such as rocks, sand, and mud on the sea floor; salts, oxygen, and nutrients dissolved in the water; and waves, currents, and light that affect the distribution of organisms. The biological components include all of the living organisms in the oceans, ranging from microscopic bacteria to giant fish and mammals, such as sharks and whales. It is the biological component of our oceans that comprise our living marine resources. Living marine **resources** include all of the organisms that are utilized by humans, such as for **harvesting** or recreational uses. Most of the organisms are harvested for human consumption, but they also provide many other products and materials. For example, marine chemists extract compounds from marine organisms, such as sponges and algae, for use in products, such as drugs and cosmetics. Many people use living marine resources for sport fishing, recreational diving, or for home aquariums. The agricultural industry utilizes living marine resources to produce products, such as fertilizer and animal feed. Living marine resources are a vital component of human life.



What marine resources do we commonly use?[2] (Lesson 1)

The most common use of our marine resources is for food. In fact, worldwide, 76% of the living marine resources harvested in 2002 were for direct human consumption. A wide variety of marine organisms are harvested from the sea for human consumption. Examples include seaweeds, jellyfishes, sea urchins, sea turtles, seals, and even polychaete worms. However, the vast majority of the marine resources harvested are fishes, constituting approximately 84% of the total world catch. **Shellfish**, **mollusks**, and **crustaceans** are also an important component of the catch. Although the size of the catch for shellfish is smaller than fishes, the value of the catch is generally greater than that for fishes.

Living marine resources constitute only 1% of all the food eaten in the world, with the rest produced on land. However, because seafood is rich in protein, it is a very important food source for human populations. Fishes provide 16% of the animal protein consumed by humans worldwide. Compared to the thousands of species of fishes and shellfish in the sea, relatively few species represent major fisheries. The largest catches in the world are comprised of small **plankton-feeding clupeoid** fishes, including herrings, anchovies, sardines, menhadens, and shads. These fishes are eaten fresh, canned, or pickled. Most of the catch for these fishes; however, is ground into **fishmeal**, a protein supplement used in feed for livestock, poultry, and farmed fishes. Bottom-dwelling, cold water fishes, such as cods, pollock, haddock, hakes, and whiting, are another important component of the world catch. The walleye pollock is the largest fishery in U.S. waters. Canned mackerel from areas, such as Japan, South America, and other parts of the world, have become an important source of inexpensive protein in some areas. Salmon species are a very valuable catch. Although the numbers caught have been in decline, the salmon fishery is still important in the North Pacific in terms of monetary value of the catch. While a large proportion of the fisheries catch occurs over **continental shelves**, many important fisheries exist in the open ocean.

The most economically important open-ocean fishery is for several species of tuna. Skipjack, yellowfin, albacore, bigeye, and bluefin tunas sell for high prices in world markets. For example, a single large bluefin tuna can sell for more than $100,000. These fishes are eaten either canned, or raw, as *sashimi,* especially in affluent countries.

Mollusks are the second most valuable group of harvested marine resources after fishes. **Cephalopods**, such as octopuses and squids, comprise the largest component of the mollusk catch. They are especially prized in Asian and Mediterranean countries. Other important harvested mollusks include clams, oysters, mussels, scallops, and abalones. Crustaceans, such as lobster, shrimp, and crab, comprise the other group of shellfishes. These shellfishes are highly prized and consumed worldwide. There are many other groups of marine organisms that are harvested, although they do not contribute much to the global fisheries production. For example, seaweeds are eaten in many Asian countries. Sea urchins are harvested for their gonads, or **roe**, which are eaten raw. There are traditional fisheries for marine mammals, such as seals and whales, in the Arctic, North Atlantic, West Indies, and the South Pacific. Marine mammals are now protected under the Marine Mammal Protection Act and can no longer be caught. Marine mammals are important components of a healthy and biologically diverse ecosystem. Overfishing or killing of any species can be devastating to an entire ecosystem. Green sea turtles (*honu*), now a protected species, historically were part of the diet of many Pacific Islanders, including the ancient Hawaiians. More information on *honu* can be found at:
www.wpcouncil.org/protected/Documents/Brochures/FINAL_Green%20Sea%20Turtle.pdf .
For a wide range of information on fisheries of the world, see:
www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=16063 .
This website is fairly technical, but has an abundance of information pertaining to aquaculture and fisheries.

Where in the marine environment are most living marine resources extracted?[3] (Lesson 1)

A majority of the world's major fisheries are located in coastal waters. Coastal waters lie over the continental shelf. Due to higher nutrient concentrations, **primary production** is greater over the continental shelf as compared to open-ocean waters. The greater amount of primary production supports a larger amount of life. The waters over continental shelves are relatively shallow, making it easier to harvest bottom-dwelling, or demersal, species. However, fisheries over the continental shelf also include **pelagic** animals, such as tunas, squids, and other organisms. Coastal fisheries are particularly significant where the continental shelf is wide, such as the Grand Banks of Newfoundland, the North Sea, and the Bering Sea. Larger fisheries are also likely to occur along the coasts of industrial nations, which have more advanced fishing capabilities compared to developing countries. Although the majority of the major fisheries occur in coastal waters, open-ocean, or pelagic, fisheries are very valuable. For example, areas of **upwelling** just beyond the continental shelf, such as Peru and northwest Africa, support some of the richest fishing areas in the world. Fisheries for migratory animals, such as tunas, can extend far out into the open ocean.

What types of living marine resources are extracted from Hawaiian waters?[4] (Lesson 1)

A wide variety of marine life is harvested from the waters surrounding the Hawaiian Islands. Similar to global fisheries, the majority of marine life that is commercially harvested are fishes. Included are pelagic fishes, deep-water bottomfishes, and reef-associated inshore fishes. Of the 25 million pounds of marine life harvested by commercial fisheries in 2005, more than 20 million pounds consisted of pelagic fishes. Of the pelagic fishes, tunas contributed more than 14 million pounds to the total catch. Other significant catches for pelagic fishes included swordfish (more than 2 million pounds), marlin species (more than 1 million pounds), and mahimahi and opah (more than 1 million pounds each). Although sharks are not targeted by any fisheries, they are often caught as **by-catch**, and occasionally sold for food. Mako sharks comprise the majority of the shark species caught at more than 140,000 pounds. By-catch occurs when organisms are caught unintentionally while fishing for other species.

There are many negative effects of by-catch. Sea turtles are frequently caught as by-catch, but there are techniques and equipment that fisherman can use that can decrease by-catch, such as using large circle hooks instead of J-hooks, using fish bait instead of squid bait, and using excluder devices, such as a Turtle Excluder Device (TED), when trawling can help expel by-catch, such as seals and turtles. A TED is a grid of bars that opens at either the bottom or top of a trawl net, allowing larger animals to escape after being caught in the net. Fisherman should be encouraged, or required, to use these techniques. Deep-water bottomfishes are also another important fishery in Hawaiʻi, although contributing much less to the total commercial catch, compared to pelagic fishes. The three most important deep-water bottomfishes include the green jobfish (*uku*, *Aprion virescens*), the ruby snapper (*ʻulaʻula or ʻehu*, *Etelis carbunculus*), and the pink snapper (*ʻōpakapaka*, *Pristipomoides filamentosus*), each contributing more than 100,000 pounds to the total commercial catch. *ʻŌpakapaka* are among the most highly prized food fishes.

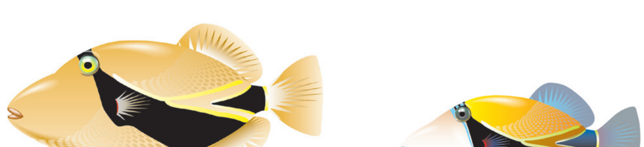
Smaller fisheries exist for reef-associated inshore fish species. Species, such as the thicklipped jack (*lehe*, *Pseudocaranx cheilio*), giant trevally (*ulua aukea*, *Caranx ignobilis*), yellow bar parrotfish (*uhu*, *Calotomus zonarchus*), yellowfin goatfish (*weke ʻula*, *Mulloidichthys vanicolensis*), eyestripe surgeonfish (*palani*, *Acanthurus dussumieri*), soldierfishes (*ʻūʻū*, *Myripristis spp.*), and chubs (*nenue*, *Kyphosus spp.*), are the major contributors to this group. Other animals, such as the kona crab (*pāpaʻi kua loa*, *Ranina ranina*), green spiny lobster (*ula*, *Panulirus penicillatus*), day octopus (*heʻe mauli*, *Octopus cyanea*), *ʻopihi* (*Cellana spp*), and various seaweeds (*Limu*), are commercially harvested as well. For a detailed analysis of the commercial fisheries catch in Hawaiʻi, see http://hawaii.gov/dlnr/dar/pubs/cmlstr2007.pdf.

What are finfish? How does human consumption of finfish affect associated marine ecosystems?[6] (Lessons 2 and 3)

Finfish is a term used in fisheries by scientists to separate true fish from non-fish, such as shellfish, jellyfish, crayfish, and others. Like all marine organisms, finfish are part of the **food chain** and eat a variety of other organisms. Some finfish are **herbivores**, like surgeonfish, and eat only plant material. Other finfish are **carnivores**, like the tunas, and eat other animals, while some finfish are **omnivores**, like goatfish and parrotfish, which eat both plants and other animals. Herbivorous finfish are generally low on the food chain, because plant material forms the base of the food chain. Omnivorous finfish are generally higher in the food chain than herbivorous finfish. In addition to eating plant material, they also eat other animals that feed on the plant material, creating another link in the chain. Carnivorous finfish are even higher on the food chain, because they only eat other animals. The higher up in the food chain a finfish is, the more links it is away from the base of the food chain. **Apex predators**, like jack trevally, are at the top of the food chain, where the only predators an apex predator may have are humans. Just as finfish eat a variety of other organisms, they can also be eaten by a variety of organisms. Smaller finfish are usually eaten by bigger finfish. This trend continues up the food chain. However, humans eat finfish at all levels of the food chain.

Human consumption of finfish and shellfish can have varying degrees of effects on marine ecosystems, depending on a variety of factors. Like all living things, organisms we harvest from the sea can reproduce to replace those taken. Because these living resources can replace themselves, they are called **renewable resources**. If the number of organisms removed from an ecosystem is greater than the number of young born into the ecosystem through a process known as **overfishing**, the population size of the species in the ecosystem will decrease. As the population size decreases, more resources, such as food and space, are available for other species in the ecosystem. The population size of these other species then has the potential to increase. The consequences of overfishing in an ecosystem can include changes in **abundance** of species and **biodiversity** in the ecosystem. Unfortunately, the consequences of overfishing depend on the species that are overfished and the dynamics of the ecosystem, which makes understanding these potential consequences extremely difficult. Therefore, it is pertinent that fisheries and fisheries managers utilize available science, and aim to harvest marine species in a sustainable way.

It is important to harvest fish sustainably to ensure that we maintain the basic ecological processes and food chains that marine life and we depend on, and to be able to provide a sustainable food source to people. Fishermen can harvest sustainably by using best practices to reduce by-catch, reduce or eliminate fishing gear that destroy habitat, and abide by



fishery management policies that aim to allow more sustainable harvesting. Policies that can result in better fish stock management and, therefore, more sustainable harvest, can include: implementing temporal closures (amount of time fisheries are open), implementing spatial closures (area available for fishing), increasing the size of fish that fishermen are allowed to keep setting aside marine reserves/protected areas to control fishing effort and catch quotas, protect important habitat, and help restore populations of fish species. For additional information concerning sustainable harvesting and the potential consequences of over-fishing, see: www.seachoice.org
http://qed.econ.queensu.ca/pub/faculty/garvie/eer/somma.pdf
http://oceanservice.noaa.gov/websites/retiredsites/natdia_pdf/7hourigan.pdf

What are some pros and cons of eating living marine resources? What are the dietary recommendations? (Lesson 3)

Seafood, especially fish and shellfish, is a beneficial component to a healthy diet. Fish and shellfish are known to offer multiple nutritional benefits. They are high in protein, low in saturated fat, and they contain many other nutrients that are important to optimal growth and development. In addition, they contain omega-3 fatty acids. Evidence suggests that there is an association between the consumption of these fatty acids in fish and reduced risks of human mortality from cardiovascular disease. There are, however, some risks to consuming seafood. For example, ciguatera fish poisoning (CFP) can result from eating reef fish that graze on algae that have toxin producing dinoflagellates associated with it. The toxin levels increase in the higher predators, because it builds up through the food chain through a process called **biomagnification**. Organisms that eat toxic substances experience *bioaccumulation*, where the toxic substance builds up within the organism over time, but doesn't kill them. As higher order animals eat many of the lower order organisms containing toxins, the higher order animals get the cumulative toxin effect, or *biomagnification*. CFP can cause gastrointestinal, neurological and cardiovascular problems and, in extreme cases, can be fatal. Once mostly limited to tropical and subtropical coral reefs, CFP has now become more of a global occurrence due to ciguatera-containing fish being exported across the world. More information on CFP can be found at www.chbr.noaa.gov/PMN/resfsgtoxicus.htm .

Another emerging issue is that nearly all fish and shellfish contain varying levels of methylmercury, which is a heavy metal toxin. Mercury can get into the water through pollution and other natural sources. Atmospheric deposition of these sources of mercury can circulate for years and be widely distributed. Sources of mercury pollution include alkali and metal processing, coal incineration, medical and other waste, and gold and mercury mining. Natural sources of mercury include volcanoes, geologic deposits of mercury, volatilization from the ocean, rocks, sediment, and water. Soils contain small, but varying amounts of mercury. For more information on mercury, see U.S. Geological Survey. Mercury in the Environment. Fact Sheet 146-00 (October 2000). http://www.usgs.gov/themes/factsheet/146-00/

For most adult humans, the risk of mercury poisoning by eating fish and shellfish is not a health concern. However, some fish contain higher levels of mercury that may harm an unborn baby or young child's developing nervous system. It is recommended that two servings of fish per week should be included in a healthy balanced diet. Further recommendations have been made for pregnant women and young children to prevent the harmful effects of mercury. These recommendations include: (1) Do not eat shark, swordfish, king mackerel, or tilefish, because they contain high levels of mercury, (2) Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are low in mercury, and (3) Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch from local waters, but do not consume any other fish during that week. For additional information concerning the importance of fish in a balanced diet, see http://www.nmfs.noaa.gov/fishwatch/seafood_and_health.htm.

What is a Fishery?[9] (Lesson 4)

A **fishery** is a defined geographic area that is associated with a population of aquatic organisms (fish, mollusks, crustaceans, aquatic plants, etc.), which are harvested for their commercial, recreational, or traditional (subsistence) value. Fisheries can occur in either freshwater or seawater, and rely on either wild or captive (farmed) stocks of organisms.

In Hawai‘i, there are several important commercial fisheries. For example, the National Marine Fisheries Service (NFMS) regulates 105 longline fishing vessels that operate in Hawaiian waters. These fishing boats target pelagic fish species, such as *ahi* tuna as well as swordfish, whose combined sales generate more than $55 million annually. NMFS works with fishermen and other government agencies to help ensure the sustainability of this fishery and; at the same time, protect turtles, birds, and marine mammals from being accidentally taken as by-catch. The State of Hawai‘i Department of Land and Natural Resources (DLNR), in partnership with the National Oceanographic and Atmospheric Administration (NOAA) and the U. S. Fish and Wildlife Service (USFWS), also maintain an extremely limited fishery in the *Papahānaumokuākea* Marine National Monument (Northwestern Hawaiian Islands). The fishery allows a limited take of deepwater snappers, including the popular food fish *‘ōpakapaka* as well as small numbers of pelagic fish, including *ahi* tuna caught by trolling fishermen. As part of the conservation-based management plan for the monument, the bottomfish fishery is being phased out over the next several years.

In the main Hawaiian Island chain, DLNR also regulates a limited bottomfish fishery that includes *‘ōpakapaka*, *hāpu‘upu‘u*, *ehu*, *onaga*, and *uku*. Fishermen are allowed to catch a limited number of these economically-important fish only from November to April, when they are not actively spawning. Recreational harvesting of invertebrate species, such as the spiny (*ula*), slipper lobsters (*ula pāpapa*), and the kona crab, are also strictly regulated by the State, and only animals without eggs can be taken from August to May. *‘Opihi* is also a regulated invertebrate species and only animals of adequate size can be taken. Even harvesting marine algae or limu is regulated, and the State’s fishery allows small amounts of *limu* to be taken per day for home consumption.

Although there are no recreational fishing license requirements for most marine animals in Hawai‘i, DLNR has a variety of size and bag limit restrictions on most of the heavily-fished species. Interestingly, there are a variety of alien or introduced predatory freshwater fish that are actually regulated by DLNR’s Division of Aquatic Resources (DAR). DAR closely monitors the populations of large- and small-mouth bass, channel catfish, rainbow trout, tucunare, oscars, and bluegill sunfish in freshwater streams, reservoirs, and ponds throughout the State. In some cases, DAR actively cultures these animals for release in an effort to maintain these populations for recreational fishermen.

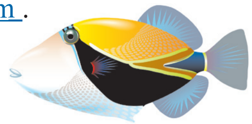
Native freshwater fish, such as the stream gobi (*‘o‘opu*) are strictly regulated and only a very limited take is allowed. Taking native freshwater invertebrates, such as *hīhīwai*, *hapawai*, and *‘ōpae*, is completely prohibited due to their low abundance and their limited habitat.

Ancient Hawaiians had rules regarding the take of aquatic species in history and maintained control of fisheries through the *kapu* system, which prohibited the harvesting of certain fish, shellfish, and algal species during critical reproductive seasons of the organisms. This conservation practice allowed the populations of these vital stocks to remain at harvestable levels by preventing overfishing and, thus, ensured the survival of the people. Also, the extensive farming of fish in Hawaiian fish ponds created an alternate man-made fishery, which eased the strain on natural stocks.

For more information on fisheries terminology see:
http://www.nefsc.noaa.gov/techniques/tech_terms.html

How do we know whether a fish population is increasing or decreasing? (Lesson 4)

One of the critical pieces of information required to manage fish populations is having an idea of how many fish are out there. While it is often difficult to obtain an actual count, it is relatively easy to get an estimate of population abundance relative to some other point in time. Fisheries scientists utilize both fisheries dependent and fisheries independent methods to obtain these measures of relative abundance. Fisheries dependent methods utilize records kept by fishing vessels and fishermen on how many fish they have caught, relative to how much effort they put into catching those fish, called catch-per-unit-effort (CPUE). CPUE can then be compared to previous years to determine whether fish populations are increasing or decreasing. One of the advantages of using data collected by fishermen is that these data are collected at no cost to the scientists and contribute to a large database with which scientists can work. The disadvantages of utilizing data collected by fishermen is that there is no guarantee that the records are accurate, that species may be misidentified, and the type of gear used for fishing may not be the same over time, all of which can complicate scientific analyses and, thus, conclusions. These problems are addressed by using independent methods of measuring fish abundance. In this case, scientists conduct their own fishing surveys to determine CPUE. The disadvantage of these surveys is that they are often time-consuming and very expensive, especially if conducted over long time periods. For additional information concerning the status of many fish stocks in the U.S., see: www.nmfs.noaa.gov/fishwatch/index.htm .



Why are living marine resources in decline?[8] (Lesson 4)

Fish populations around the world are in decline, primarily due to overfishing. It has been estimated that 70% of all marine commercial fisheries are fully exploited or depleted, and at least 25% or more of these fisheries are overexploited or even exhausted. Recent studies have shown that approximately 90% of the biggest fishes in the world's oceans have been harvested, taken by big commercial fishing fleets. This problem is not confined to traditional major fisheries of the world; small-scale local fisheries in the tropics also are being rapidly decimated. The fish that do remain are also smaller than prior to the advent of modern intensive fishing methods. Small females produce fewer eggs than larger females. Furthermore, at least in some species, larvae from small females are smaller and grow slower than larvae from larger females.

Habitat destruction and the inadvertent by-catch of large fish with little food value also contribute to the decline of marine fish populations. Habitat destruction is a growing threat to fishery resources. Estuaries, mangroves, seagrass beds, and other coastal habitats are critical breeding grounds and nurseries for many marine species. A large proportion of the commercial fisheries catch is comprised of species that utilize these habitats during some stage of their life history. Trawls dragged along the bottom devastate sea floor habitats. Habitat destruction also occurs in the form of pollution from oil spills, sewage, and toxic chemicals. By-catch occurs when organisms are caught unintentionally while fishing for other species. It is estimated that 25% of the world catch is by-catch. Examples of by-catch include turtles, seabirds, dolphins, and other marine life caught on long lines, consisting of a series of baited hooks attached to a long line, sometime up to 60 miles in length. Trawling, a fishing method that utilizes a net dragged along the sea floor, also produces a lot of by-catch. This is particularly true in shrimp fisheries where as much as 95% of the catch is by-catch, because of the small size of the net's mesh. Most of the by-catch is discarded. Even if by-catch animals are released alive, most of them eventually die due to stress and injuries sustained during and after capture. For additional information concerning the by-catch problem, see: http://seagrant.gso.uri.edu/factsheets/Bycatch.html.

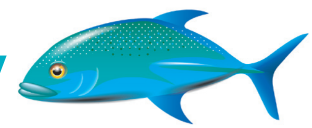
How do energy pyramids help us understand cycling of matter? (Lesson 2)

An energy pyramid is a diagram of the trophic levels (nutritional) by which incoming solar energy is transferred into an ecosystem. The source of energy for living organisms on Earth is the Sun. Typically, an energy pyramid shows the amount of energy produced by producers, primary consumers, secondary consumers, and tertiary consumers (top predators) in an ecosystem. The bottom level of the pyramid, the producers, include plants, algae, protists, and other organisms that use photosynthesis to make energy. As primary consumers, such as insects, crustaceans, and other herbivores, eat the producers, most of the energy from the producers moves into the primary consumers. Not all the energy moves to the primary consumer level, though. Some of the energy is lost to the atmosphere as heat. This is due to the heat and energy used by the primary consumer to consume and digest the producer. Secondary consumers, such as birds, *ulua*, and other carnivores, eat the secondary consumers, thus transferring the energy of the primary consumers to the secondary consumers. Again, some of the energy from the primary consumers is lost as heat energy when the secondary consumers eat. The top level of the energy pyramid is the tertiary producers (the top predators), which are predators that eat other predators. In an energy pyramid, the continual loss of energy due to metabolic activity from one level to the next puts limits on how much energy is available to higher trophic levels.

An energy pyramid is different than a biomass pyramid or numbers pyramid. Typically, food chains can be represented through biomass or numbers pyramids. These pyramids show the relative level, or number, of organisms of each category in each level. For example, in the ocean, phytoplankton is the primary producer. There is a significantly greater amount of phytoplankton in the ocean in terms of both quantity and biomass than any other level organism. So, on a biomass pyramid, the plankton would be the large bottom level of the pyramid. It takes this amount of biomass to sustain the organisms at the next higher level.

In an energy pyramid, decomposers play an interesting role. Decomposers, such as bacteria and fungi, draw energy from each level of the pyramid. They then cycle the energy from the higher level consumers back down to the producer level. In this way, energy cycles through an ecosystem. This cycling of matter occurs on both energy (food) and chemical levels. Carbon and nitrogen cycle through an ecosystem through the process of production, consumption, and decomposition as well.

Science Background for the Teacher Glossary



abundance: the number or amount of something.
apex predator: predators that are not preyed upon themselves; often at the end of long food chains, where they have a crucial role in maintaining and determining the health of ecosystems.
aquaculture: refers to the breeding, rearing, and harvesting of plants and animals in all types of water environments, including ponds, rivers, lakes, and the ocean.
bioaccumulation: when the input of a toxic substance in an organism is greater than its removal.
biodiversity: the relative abundance and variety of plant and animal species within a habitat.
biomagnification: increase in concentration of a toxic substance from one link in a food chain to another.
by-catch: species caught in a fishery that targets other species.
byssal thread: strong threads secreted by mussels to attach to rocks and large, generally heavy objects in the intertidal zone.
capture-recapture method: two-sample model, used solely to estimate the unknown size of a population.
carnivore: an animal that eats other animals.
cephalopod: mollusks, such as an octopus, squid, or nautilus, having a beaked head, an internal shell in some species, and prehensile tentacles.
clupeoid: soft-finned schooling food fishes in shallow waters of northern seas.
continental shelf: the zone bordering a continent, extending from the line of permanent underwater immersion to the depth at which there is a marked or rather steep descent to the great ocean depths.
crustacean: a class of invertebrates, including crabs, lobsters, and shrimp that have a segmented body, a hard external skeleton (exoskeleton), two sets of antennae, and one pair of legs per body segment.
demersal: living on the sea floor or just above it.
finfish: a term used in fisheries science to separate true fish from non-fish, such as shellfish, jellyfish, crayfish, etc.
fish aggregation device (FAD): is a man-made object, like a buoy or a float, used to attract ocean going pelagic fish, such as marlin, tuna and mahi-mahi.
fish meal: ground dried fish used as fertilizer and as feed for domestic livestock.

fisheries: the sum of all fishing activities on a species in a defined area.
food chain: the relationship between plants and animals that shows who eats what.
harvest: the total number or poundage of fish caught and kept from an area over a period of time.
herbivore: animal that eats only plant material.
mariculture: the farming of marine species.
mollusk: invertebrate animals with soft, un-segmented bodies, such as clams and snails, usually enclosed in a calcium shell.
omnivore: animal that eats both plant and animal material.
overfishing: the harvesting of a particular species of fish to the point where it can no longer replace itself in large numbers through reproduction in a given area; the rate at which natural replenishment of the species can no longer keep up with extraction.
pelagic: fish and animals that live in the open sea, away from the sea bottom.
plankton: a diverse group of animals (zooplankton) and plants (phytoplankton) that freely drift in the water.
primary production: the process by which organic matter is produced by plants from inorganic matter and energy from the sun through photosynthesis.
renewable resource: a natural resource (such as trees and fish) that can be replenished or replaced by natural processes.
resource: a person, thing, or action needed for living or to improve the quality of life.
roe: eggs of fish and invertebrates.
shellfish: general term for crustaceans and mollusks.
upwelling: a process in which cold, often nutrient-rich waters from the ocean depths rise to the surface.

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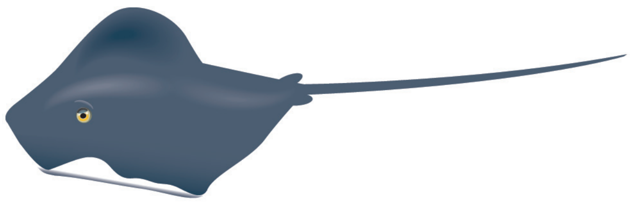

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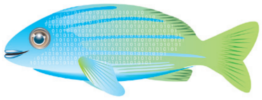

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NOAA Resources

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:

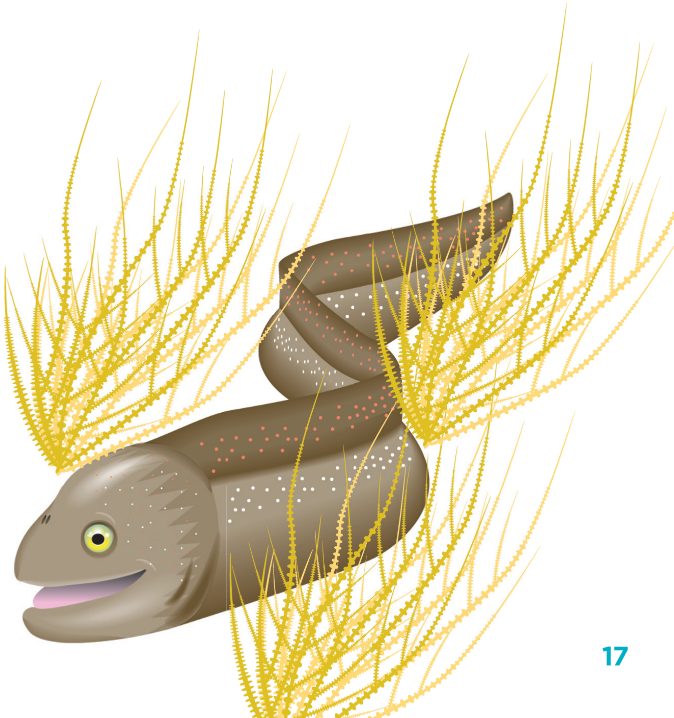
Outreach Unit
NOAA Office of Public and Constituent Affairs
1305 East West Highway #1W514
Silver Spring, MD 20910
Phone: (301) 713-1208
Email: NOAA-OUTREACH@noaa.gov
http://www.education.noaa.gov/

Resources:

- Channel Islands Marine Reserves Digital Lab found at
  http://www.jason.org/digital_labs/CINMS/

- Oceans for Life: Marine Protected Areas in California lesson plan and complimentary video found at
  http://www.oceanslive.org/portal/index.php?module=pagesetter&func=viewpub&tid=3&pid=28

- "Why is Hawai'i's Ocean Important?: A Keiki Activity Book" University of Hawai'i/NOAA



OCEAN LITERACY ESSENTIAL PRINCIPLES

1. The Earth has one big ocean with many features.
   1h. Although the ocean is large, it is finite and resources are limited.

5. The ocean supports a great diversity of life and ecosystems.
   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.

6. The ocean and humans are inextricably interconnected.
   6b. From the ocean, we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
   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 lead 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.

7. The ocean is largely unexplored.
   7b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
   7c. Over the last 40 years, use of ocean resources has increased significantly; therefore, the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
   7d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
   7f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Lesson 1: 5d. 6b. 6e.
Lesson 2: 5d.
Lesson 3: 5d. 6b. 6e.
Lesson 4: 1h. 6b. 6e. 6g. 7b. 7c. 7d. 7f.

CLIMATE LITERACY ESSENTIAL PRINCIPLES

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

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 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

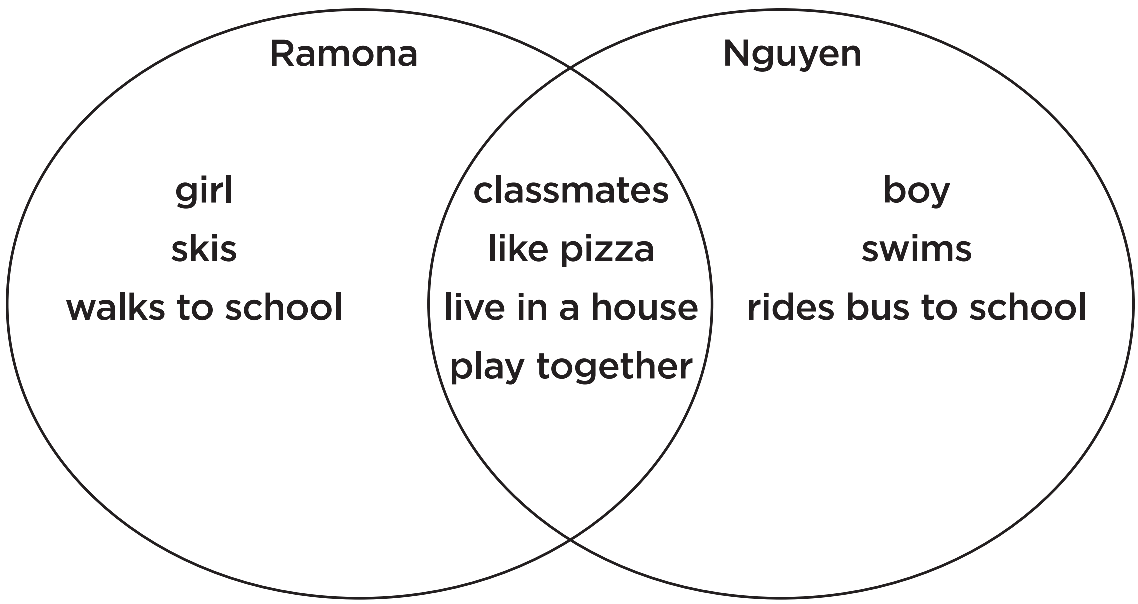
Round table can be used for brainstorming, reviewing, or practicing while also serving as a team builder. Students sit in teams of 3 or more, with one piece of paper and one pencil. The teacher asks a question which has multiple answers. Students take turns writing one answer on the paper, then passing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



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