GRADE 4 UNIT 7 OVERVIEW
Marine Protected Areas

Introduction

Marine protected areas are important for the protection of coral reef habitats and the perpetuation of healthy ecosystems throughout the world. The practice of designating a marine protected area is often misunderstood by the general public; people often associate the creation of such areas, and associated governmental regulations, with total prohibition of human access and use of these areas. Although a few marine protected areas are designated *no-access* areas, most of them are simple cautionary measures designed to make the general public aware of the importance of having healthy ecosystems. Hawaiʻi has its share of marine protected areas, but only one *no-access* area, the Northwestern Hawaiian Islands *Papahānaumokuākea.* It is also one of the world's largest marine protected areas.

Throughout this unit, students progressively become acquainted with marine habitats and fragile ecosystems and what they need to survive. They also learn about natural events such as wind, waves, storms, and tsunamis, which can severely impact marine habitats and disturb, and even destroy habitats and ecosystems. Although these effects can be devastating, they are not very frequent. Students also learn that human activities impact marine habitats and ecosystems because of over-fishing, water pollution, use of trawling fishing techniques, and many others. They also find that, although natural events cannot be prevented, impacts caused by humans can be somewhat curbed through the creation of marine protected areas.

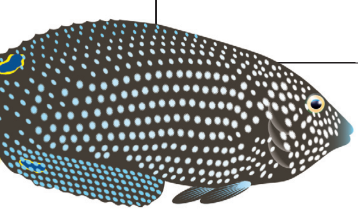
As part of a marine protected area (MPA) research project, students select a MPA in the United States and, following extensive Internet searches, compile specifics about their selection, describe the MPA, and point out how the introduction of certain regulations might motivate people to use protected areas with care. Students then write a short report about their MPA that also includes a visual portion for posting on a gallery walk.

In culminating exercises, students review the information they compiled about healthy marine ecosystems during brainstorming, viewing of videos, completing student worksheets, contributing to classroom displays, and other sources. They are then asked to demonstrate their understanding of marine restricted areas by creating a marine protected area for the habitat they created, listing rules that should be applied, taking into account projected benefits, and anticipated public objections.

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 makes a marine ecosystem healthy? What are some natural events that impact marine ecosystems?	Science Standard 3: Life and Environmental Sciences: SC.4.3.2: Describe how an organisms behavior is determined by its environment.	**Lesson 1: What Makes a Healthy Marine Ecosystem?** Through a video, the Internet, and the creation of a brainstorming web, students are introduced to marine ecosystems. By the end of this lesson students will be able to draw a healthy marine ecosystem with description of a threatened, protected, or endangered animal and explain why its habitat is important. The drawing will also include a description of the effects of natural events like storms, wind, waves, and tsunamis on these ecosystems. Two 45-minute periods
How do humans impact marine ecosystems?	Science Standard 3: Life and Environmental Sciences: SC.4.3.2: Describe how an organisms behavior is determined by its environment.	**Lesson 2: In What Ways Do Humans Impact Marine Ecosystems?** The concept of how humans impact healthy marine ecosystems is introduced in this lesson by building on knowledge from the previous lesson. Students identify two major ways in which human beings impact marine ecosystems and give examples. Students augment their drawings of a healthy marine ecosystem with human impacts. Two 45-minute periods



ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	LESSON, *Brief Summary*, Duration
How do we protect our marine environments? What is a marine protected area?	Science Standard 3: Life and Environmental Sciences: SC.4.3.2: Describe how an organisms behavior is determined by its environment.	**Lesson 3: What Is A Marine Protected Area?** Students are introduced to marine protected areas. In this lesson students will apply previous knowledge to understand why marine protected areas are necessary. To show what they have learned students will then add to the illustration created in Lesson 1 making sure to describe what a marine protected area consists of as well as how it will protect the organisms in their created ecosystem. Two 45-minute periods
How do we decide the areas that need protection and the level of protection needed? What is life like in a marine protected area?	Science Standard 3: Life and Environmental Sciences: SC.4.3.2: Describe how an organisms behavior is determined by its environment. Language Arts Standard 2: Reading Comprehension LA 4.2.5: Summarize main points found in informational texts Language Arts Standard 4: Writing: Conventions and Skills LA 4.4.1: Write in a variety of grade-appropriate formats for a variety of purposes and audiences	**Lesson 4: Marine Protected Areas All Over…** This lesson gives students a chance to independently explore a marine protected area in the United States and write a report about it for the class. The report includes a visual component. One 45-minute period

ESSENTIAL QUESTIONS	HCPS III BENCHMARKS	LESSON, *Brief Summary,* Duration
Why is it important to create Marine Protected Areas?	Science Standard 3: Life and Environmental Sciences: SC.4.3.2: Describe how an organisms behavior is determined by its environment. Language Arts Standard 4: Writing: Conventions and Skills LA 4.4.1: Write in a variety of grade-appropriate formats for a variety of purposes and audiences Language Arts Standard 4: Writing: Conventions and Skills LA 4.4.7: Write a simple bibliography entry for a book and website	**Culminating Lesson: Creating a Marine Protected Area** Students demonstrate their knowledge of marine protected areas by creating point-of-view persuasive essays that focus on the class marine environment model. Students may also participate in a mock neighborhood board meeting where they share their points of view in oral presentations. From these essays, students will be able to design an MPA for the marine environments they created in Lesson 1. Two 45-minute periods

**HCPS III Benchmarks from the Hawai'i Department of Education, from Website: http://doe.k12.hi.us/standards/index.htm*

Benchmark Rubric

I. HCPS III Benchmarks*

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

Topic		**Interdependence**	
Benchmark SC.4.3.2		Describe how an organism's behavior is determined by its environment	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Explain and give examples of how different organisms' behaviors are determined by their environments	Describe how an organism's behavior is determined by its environment	Identify a way that an organism's behavior is influenced by its environment	Recognize that an organism's behavior is influenced by its environment

Topic		**Constructing Meaning**	
Benchmark LA.4.2.5		Summarize main points found in informational texts	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Summarize the main points and describe their connection to the main idea or focus in informational texts	Summarize the main points found in informational texts	Produce a summary that mixes insignificant points with main points	Summarize information not necessary to understanding the main points of informational texts, or repeat original text rather than summarize

Topic		**Range of Writing**	
Benchmark LA.4.4.1		Write in a variety of grade-appropriate formats for a variety of purposes and audiences, such as: • narratives that follow a plot and describe a setting and characters • poems that provide insight into why the topic is memorable • responses to literature • reports that focus on a central question and incorporate summaries from research • accounts based on personal experience that have a clear focus and supporting details • 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		**Citing Sources**	
Benchmark LA.4.4.7		Write a simple bibliography entry for a book and website (e.g., author, title, publisher, copyright)	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Write a simple bibliography entry, with accuracy and completeness	Write a simple bibliography entry, with no significant errors	Write a simple bibliography entry, with one or two missing elements or several errors in style	Write a simple bibliography entry, with most elements missing or many errors in style

Topic		**Discussion and Presentation**	
Benchmark [LA.4.6.2]		Give short, informal presentations to inform or persuade	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Give creative, short, highly effective informal presentations to inform or persuade	Give short, informal presentations to inform or persuade	Give short, informal presentations that are somewhat informative or persuasive	Give short, informal presentations that do not inform or persuade

II. General Learner Outcomes*

Below is a list of the Hawai‘i Department of Education (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 makes a healthy marine ecosystem? (Lesson 1)

Marine ecosystems are composed of both physical and biological components. The physical components include all of the non-living, or **abiotic** structures and processes such as rocks, sand, and mud on the sea floor; salts, oxygen and nutrients dissolved in the water, as well as waves, currents, and light which affect the distribution of organisms. The biological or biotic components include all of the living organisms in the oceans ranging from microscopic bacteria to giant fish, sharks and mammals such as dolphins and whales. The composition of marine ecosystems is highly dependent on the interactions between these abiotic and biotic components. Marine ecosystems are negatively affected by **anthropogenic** or human effects such as over-fishing, pollution, and destruction of habitat. The interaction of these abiotic, biotic, and anthropogenic factors determines the health of marine ecosystems.

There is no single definition of a healthy marine ecosystem, and the concept of what makes a healthy marine ecosystem is likely to change over time. As a dynamic system, *health* depends on some previous reference point against which the current ecosystem can be measured. Scientists, however, can measure the **biodiversity** and **abundance** of species in an ecosystem to get an idea of the relative overall health of the ecosystem. Biodiversity is a measure of how many different species of animals are present in an ecosystem; an ecosystem with 100 species is more diverse than an ecosystem with 10 species. Evidence suggests that greater biodiversity in an ecosystem has many benefits, leading to more efficient use of the available resources, greater production of food and oxygen, and faster decomposition of waste. Diverse ecosystems also appear to be more resilient to both natural disturbances, such as disease or climatic changes, and to anthropogenic disturbances, such as pollution, fishing pressure, or introduction of **invasive species.** Abundance is a measure of how many (or how much in terms of biomass) of a particular animal is present in an ecosystem. An ecosystem may not have changed in terms of diversity, but the abundance of each species may have changed in relation to the other species. For example, an ecosystem may contain 100 different species yet contain fewer large fish and more algae species than before. Changes in either abundance or diversity are often a sign that there have been changes in the health of the ecosystem.

The concept of healthy marine ecosystems in the Main Hawaiian Islands (MHI) has changed dramatically in recent years in response to studies characterizing the health of the Northwestern Hawaiian Islands (NWHI), the northern islands, and atolls of the Hawaiian archipelago. These studies have shown that the biomass of fish (a measure of abundance) in the NWHI is almost 300 percent greater than similar habitats in the main Hawaiian Islands. In addition, the NWHI ecosystems are dominated by **apex predators,** animals at the top of the food chain, such as sharks and jacks (eg. the giant trevally, *Caranx ignobilis, ulua aukea*). More than 54 percent of the total fish biomass in the NWHI consists of apex predators, compared to less than 3 percent in the Main Hawaiian Islands (MHI) (*Hawaiʻi, Maui, Molokaʻi, Lānaʻi, Oʻahu, Kauaʻi and Niʻihau*). Apex predators balance the ecosystem because of their position on the food chain, and their absence usually results in an overall decrease in the biodiversity of species within coral reef habitats. The isolation of the NWHI has limited the amount of human impact in these ecosystems, and the NWHI are likely representative of what ecosystems in the Main Hawaiian Islands once were. While human impacts are limited, they are not completely absent. Marine debris like trash and abandoned fishing gear that finds its way to the NWHI can endanger sea turtles, monk seals, Laysan Albatross, and other marine life through accidental ingestion and entanglement. Compared to the NWHI it seems as though the health of the MHI is heavily compromised. Most reefs are dominated by marine algae that overgrows and replaces healthy coral on the reef, limiting availability of habitat for reef fish and other reef animals. Apex predators are rare in the MHI in comparison to the NWHI, and results in reduced biodiversity.

While comparisons can be made between the NWHI and the MHI, measuring ecosystem health overall in either one of these locales depends on the reference point to which the current ecosystem is compared. For additional information on the differences in fish assemblages between the NWHI and the MHI, consult http://www.Hawaiianatolls.org/research/NWHIRAMP2004/features/predator-dominated.php

What natural disturbances are there to marine ecosystems? (Lesson 2)

Marine ecosystems are inherently variable and experience natural disturbances on a regular basis. A natural disturbance is any event not caused by humans which alters the ecosystem in some way. Natural disturbances include, but are not limited to, heavy rains, tropical storms, disease, **El Niño** events, and global climate change. Runoff generated by heavy rains can greatly increase the amount of sediments and nutrients entering coastal areas, affecting the amount of light entering the water and smothering coral reefs. The increased nutrients in the water can also lead to periods of increased algae growth. Tropical storms and hurricanes can create large, high-energy waves which cause destruction in shallow water ecosystems such as coral reefs and kelp forests. Entire pieces of coral and kelp can be washed away, creating new substrate for organisms to settle on and grow. Disease can affect large areas of an ecosystem. For example, a waterborne pathogen in the Caribbean during the 1980s caused widespread die-offs of the long-spined sea urchin *Diadema antillarum,* reducing the population by up to 95 percent. The die-off of urchins, important algae grazers, caused increased algae growth smothering coral reefs in the area. **El Niño** events cause increases in sea surface temperatures in the East Pacific Ocean, resulting in severe weather conditions around the globe such as severe storms in the southwestern USA and monsoon-like conditions in the central Pacific, including Hawai‘i. Ocean upwelling, the process by which shallow waters are replenished with deep nutrient-rich waters, ceases in some regions of the ocean during **El Niño** events, causing associated fisheries to become less productive.

Scientists predict global climate change will lead to dramatic changes in Earth’s weather and climate patterns over the next century. These include increased air and sea temperatures, rises in sea level, changes in weather patterns, more frequent storms, droughts, floods, and other extreme weather conditions in some places, and changes in the seawater chemistry due to increased carbon dioxide concentrations. Sea-level is predicted to rise up to 48 cm (~1.5 feet) by the year 2100. Rising sea levels can lead to increases in the intensity and frequency of storm surges, increased coastal erosion, and large reductions of wetland, mangrove, and coral reef ecosystems. Predicted increases in sea-surface temperatures in the range of 1.4–5.8°C (2.5-10.4° F) will have serious impacts on shallow water ecosystems, especially coral reefs. Current **coral bleaching** episodes, the loss of color from corals due to stress induced expulsion of **symbiotic zooxanthellae**, result from a 2°C (3.6°F) increase in summer maximum temperatures in many parts of the world. If sea surface temperatures increased in Hawai‘i and other Pacific Islands, bleaching could effectively wipe out all live coral on the reefs. When the coral dies, reef growth will cease, and all of the species that depend on the reef for food and shelter would be displaced and could possibly die out, seriously impacting fisheries and decreasing the protection from waves that a healthy coral reef provides.

In what ways do humans impact marine ecosystems? (Lesson 3)

The global human population has grown to more than 6 billion and continues to grow. Today, more people live within 60 miles of coastlines than people lived on the entire planet in 1950. As our population continues to expand, our impact on marine ecosystems intensifies as well. The majority of anthropogenic impacts on marine environments falls under two general categories: modification and destruction of habitats, and **pollution.**

Because there are a vast and growing number of people that live along coastlines, these areas are primarily affected by the modification and destruction of habitats through human activities. This is especially true in the tropics on coral reefs. More than one quarter of the world’s coral reefs have already been lost or are severely threatened. The clearing or deforestation of shoreline and inland areas for agriculture, logging, and urban expansion increases the amount of sediment washed into the sea through rivers and runoff. While coral can tolerate small amounts of sediment, increased amounts of sedimentation created by coastal modification and development can prevent coral growth by smothering coral, decreasing the amount of sunlight that reaches the corals symbiotic zooxanthellae. Harmful techniques used for fishing on coral reefs, such as explosives and poisons, are also detrimental. Although banned or illegal, these techniques are still used in many developing areas of the world. Other anthropogenic threats to coral reefs include the mining of coral for construction purposes, the collection of coral and reef animals for the aquarium trade, and damage caused by recreational use of coral reefs, such as walking on the reef, scuba diving, and damage caused by anchors and fishing. Other coastal areas threatened by human impacts include salt marshes and mangrove forests in estuarine environments. **Estuaries** are increasingly being dredged to make marinas and artificial harbors, or filled in for urban development. Increased wave action to estuaries caused by dredging often leads to the destruction of salt marsh and mangrove areas. Shrimp **mariculture** along tropical and subtropical shores is particularly destructive to mangrove forests. These areas are cleared to build ponds needed to grow the shrimp. Excess nutrients in the form of waste from the ponds are often washed out to sea, causing algal overgrowth on the reef. Trawling is also a destructive fishing process that modifies and destroys seafloor habitat. Trawl nets are dragged along the bottom of the sea to catch fish and invertebrates. These nets often destroy anything in their path, leaving scars in soft sediments in addition to the re-suspension of sediments. Repeated trawling leaves little chance for bottom communities to recover, which tend to shift to short-lived, fast growing animals. For additional information concerning the effects of trawling on sea floor habitats, consult http://www.whoi.edu/oceanus/viewArticle.do?archives=true&id=33769

Pollution is the other main anthropogenic impact affecting our marine ecosystems today. The major forms of pollution include excess nutrients from fertilizers, sewage, oil, and debris. Excess nutrients from fertilizers used in agriculture are often swept into the sea as runoff. Although nutrients are needed by primary producers, too much nutrients leads to **eutrophication** and accelerated algae growth in response to increased nutrient input. Eutrophication can lead to damage of coral reefs by causing an increase in phytoplankton growth, reducing the amount of sunlight reaching the bottom, and accelerating the growth of algae which can smother coral reefs. Phytoplankton blooms, a short-term rapid increase in the abundance of phytoplankton, can cause mass die-offs of animals through the creation of **anoxic** zones in coastal areas. For example, the anoxic zone in the Gulf of Mexico has reached sizes up to 22,000 km^2 (13,670 sq. miles). Sewage discharge into coastal areas can contain viruses, bacteria, and other parasites that cause diseases. Animals that concentrate these pollutants in their tissues, such as clams, oysters, and other filter feeding animals can cause sickness when these animals are consumed. Swimming in sewage polluted water can cause infections just from being in contact with the water. In recent years, the amount of beach closures due to raw sewage spills has increased dramatically. Increased nutrients in the water due to sewage discharge can also lead to eutrophication. For example, between the 1950s and 1970s, untreated municipal sewage was dumped into the southern portion of *Kāneʻohe Bay, Oʻahu.* Eutrophication of the bay caused the destruction of large portions of coral reef and a decline in reef fish populations. Increased nutrient concentrations led to increased growth of the macroalgae, *Dictyosphaeria cavernosa,* allowing it to overgrow and replace coral-dominated reef communities. Recognizing the consequences of the sewage discharge, the sewage was diverted to a deep ocean outfall in the late 1970s. The bay has since shown strong signs of recovery, but the consequences demonstrate the negative impacts that poor management of water resource quality can have on the health of the environment. Ecosystems experiencing nutrient enrichment, coupled with over-fishing, tend to be susceptible to harmful effects of invasive species.

Invasive species that become established tend to be strong competitors for food and space, and can potentially carry parasites that are also foreign to the local area, infecting the indigenous species. Over the last few decades, the number of invasive species has increased world-wide as a result of growth in the shipping industry, the introduction of fish and shellfish farming, and demand for exotic fish in the aquarium trade.

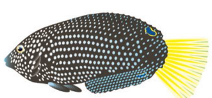
Oil is one of the most widespread pollutants in the ocean. It is estimated that more than 600 million tons of oil enter our oceans each year. Almost 85 percent of the oil entering the ocean in North America comes from river runoff, coastal cities, fuel from small boats, and fuel jettisoned by planes. However, the massive oil spills caused by the sinking or collision of supertankers is the most destructive.

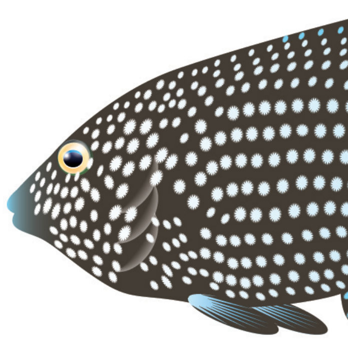
For example, the 1989 spill from the Exxon Valdez ship along the coast of Alaska released more than 35,000 tons of oil along the coast of southern Alaska. The spill caused massive destruction of coastal ecosystems and widespread mortality of marine life. Marine debris, in the form of synthetic material such as plastics, is an ongoing problem worldwide. The problem is particularly noticeable in the isolated and uninhabited areas of the Northwestern Hawaiian Islands where more than 500 tons of marine debris has been removed since 1996 under the NOAA Marine Debris Program. For additional information concerning the NOAA Marine Debris Program in Hawai‘i, consult
http://celebrating200years.noaa.gov/magazine/debris/welcome.html#history

What are ways in which marine areas can be protected? (Lesson 4)

A marine protected area (MPA) is an area of the marine environment that has been provided some form of protection for part or all of the natural resources in that area. In the United States, areas within a wide range of habitats including open ocean, coastal areas, intertidal zones, estuaries, and the Great Lakes have been designated MPA's. Besides varying by habitat, MPA's also differ in their purpose, management approaches, and restrictions placed on human use. The purpose of MPA's is to protect and sustain crucial habitats and marine resources from human impacts. Areas designated as MPA's include the Northwestern Hawaiian Islands (*Papahānaumokuākea Marine National Monument***,** one of the largest MPAs in the world encompassing 137,797 square miles of the Pacific Ocean), *Hanauma Bay*, the Great Barrier Reef in Australia, the Florida Keys, and Monterey Bay in California. MPA's usually sustain a greater diversity and abundance of species compared to unprotected areas around them. Evidence suggests that MPA's also benefit the areas surrounding them through either **seeding,** when offspring of individuals inside the MPA settle outside the area, or **spillover,** where juveniles and adults move out of the MPA into surrounding waters.

The level of protection afforded by MPA's is highly variable and depends on the specific goals of their establishment. The National Marine Protected Areas Center of the United States has established six general levels of protection which directly influence the effects of human use on the environment. These six levels of protection include:





<u>Uniform Multiple-Use</u>: includes MPA's with a consistent level of protection and allowable activities, including certain extractive uses, across the entire protected area.

<u>Zoned Multiple-Use</u>: includes MPA's that allow some extractive activities throughout the entire protected area, but use zoning to allocate specific uses to compatible places or times in order to reduce adverse impacts.

<u>Zoned Multiple-Use With No-Take Areas</u>: includes multiple-use MPA's that contain at least one zone in which all resource extraction is prohibited.

<u>No-Take</u>: includes MPA's or zones that allow human access and even some potentially harmful uses, but totally prohibit the extraction or significant destruction of natural or cultural resources.

<u>No-Impact</u>: includes MPA's or zones that allow human access, but prohibit all activities that could harm the site's resources or disrupt the ecological or cultural services they provide. Activities typically prohibited in no-impact MPA's include resource extraction of any kind (fishing, collecting, and mining); discharge of pollutants; disposal of materials; and alteration or disturbance of submerged cultural resources, biological assemblages, ecological interactions, protected habitats, or the natural processes that support them.

<u>No-Access</u>: includes MPA's or zones that restrict all human access to the area in order to prevent potential ecological disturbance, unless specifically permitted for designated special uses such as research, monitoring, or restoration.

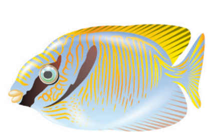
Protection in MPA's can be permanent, conditional (MPA's that have the potential to persist over time but must be actively renewed based on periodic reviews of performance), or temporary (MPA's designed to address short-term goals). Additionally, MPA's can be year-round, seasonal, or rotating (MPA's that cycle among a set of fixed areas in order to meet short-term conservation or management goals).

Listen to an interview with *Papahanaumokuakea Marine National Monument Superintendent Aulani Wilhelm* at http://www.earthsky.org/interviewpost/biodiversity/aulani-wilhelm-honors-wildlife-at-papahnaumokukea-national-monument.

For additional information concerning the national system of marine protected areas, consult http://www.mpa.gov/

What are some of the reasons why MPA's are controversial? (Lesson 5)

Although MPA's have been in effect for several decades in Western resource management circles, they only have gained emphasis as a resource management tool in recent years. MPA's have been in effect through traditional management systems for centuries in the Pacific. As with most regulatory policy, there are people who are concerned about the effects of MPA's on recreational activities, commercial fishing, and cultural rights. For example, many people hear MPA and assume it is a no-take or no-access area. However, the term MPA is a broad term encompassing a wide variety of area-based approaches to marine conservation. Less than 1 percent of U.S. waters are no-take areas. The majority of MPA's in the U.S. are multiple-use areas that often permit both consumptive and non-consumptive activities such as fishing, diving, boating, and swimming. However, areas that do restrict access to public use can cause controversy. The recent designation of the Northwestern Hawaiian Islands as a National Marine Monument was faced with this issue; all non-authorized access is restricted, and access is tightly regulated. MPA's can affect commercial fishing activities in the areas they are established. For example, all commercial fishing in the NWHI will end by the year 2011. The cessation of



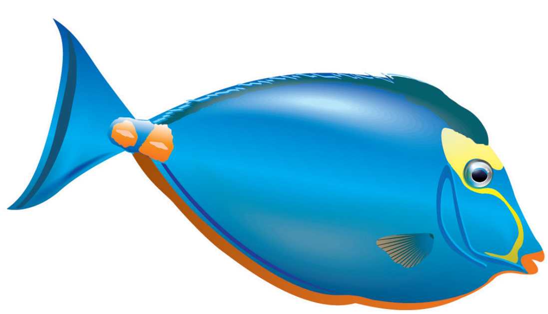
commercial fishing would eliminate the prominent bottomfish fishery in those waters. There are currently eight active licenses allowing bottom fishing in the NWHI. Because more than one-third of all Hawaiian bottomfish come from waters in the NWHI, with an estimated value of over $1 million, there are concerns that this ban will affect not only those who are permitted to fish in the NWHIs, but also local businesses, such as restaurants and fish wholesalers.

As the focus on MPA's as a management option for marine ecosystems intensifies, efforts are increasingly being made to educate the public about the potential benefits of MPA's and to minimize the effects of MPA's creation on the cultures, activities, and economies in those areas. Additionally, increased scientific study of MPA's will help to evaluate their effectiveness as marine ecosystem management tools, and to further guide governments and policymakers in their creation of MPA's. For additional information concerning the *Papahānaumokuākea Marine National Monument,* consult http://www.Hawaiireef.noaa.gov/about/welcome.html

Science Background Glossary for the Teacher

abiotic: a non-living (physical or chemical) component of the environment.
abundance: the number or amount of something.
anoxic: lacking oxygen.
anthropogenic: caused or produced by humans.
apex predators: predators that are not themselves preyed upon as a species; in the highest feeding level of a food chain or food web.
biodiversity: the variety of species in an ecosystem.
biotic: a living component of the environment.
broadcast spawning: a reproductive strategy whereby gametes (‘ga-’mēt also g’-amēt) 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.
coral bleaching: the loss of color from corals due to stress induced expulsion of symbiotic zooxanthellae.
El Niño: an inter-decadal, climatic, ocean-atmosphere coupled event that results in warmer surface waters in the East Pacific Ocean.
ecosystem: all the living populations in an area along with the nonliving parts of that environment.
estuary: semi-enclosed coastal body of water with one or more rivers and streams running into it and an open connection to the sea.

eutrophication: accelerated growth of algae in response to increased nutrient input.
herbivorous: eating only plants.



invasive species: species that enter into new ecosystems and spread, causing damage to native species and their habitats.
mariculture: farming of marine species for human use or consumption.
pollution: the introduction by humans of energy or substances that decrease the quality of the environments.
symbiotic: having a close relationship with another species.
upwelling: the process by which colder water rich in nutrients rises from a lower to a higher depth.
zooxanthellae: (zo-zan-thel-ee) dinoflagellates that live within the tissues of reef corals and other marine animals.

Science Background for Teachers - Bibliography

1-5 Science background information condensed and/or compiled from the following sources:

1: Castro, P., & Huber, M.. (2007). *Marine Biology*. New York, NY: McGraw-Hill.
Suthers, D. (2004). *A predator dominated ecosystem: Comparing the fish of the Northwestern and Main Hawaiian Islands*. Retrieved November 13, 2007, from
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2: Castro, P. & Huber, M. (2007). *Marine Biology*. New York, NY: McGraw-Hill.
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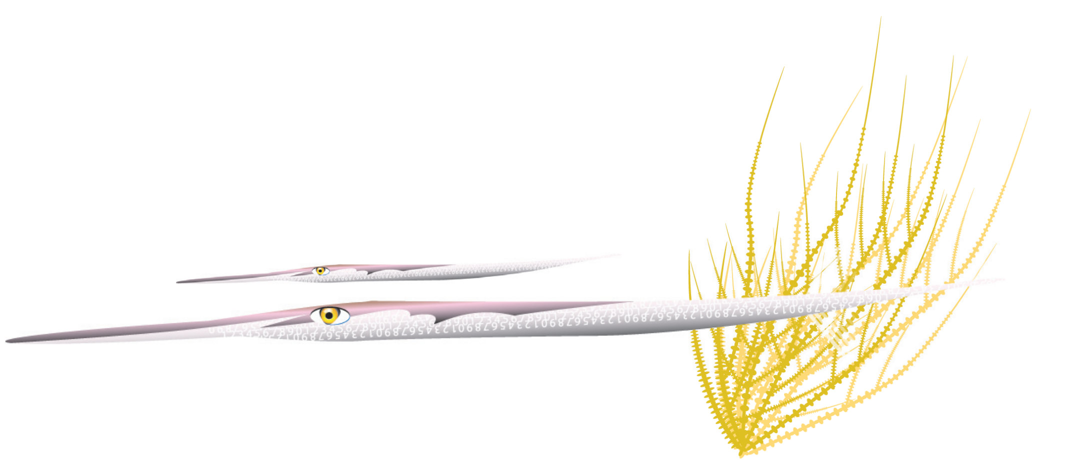


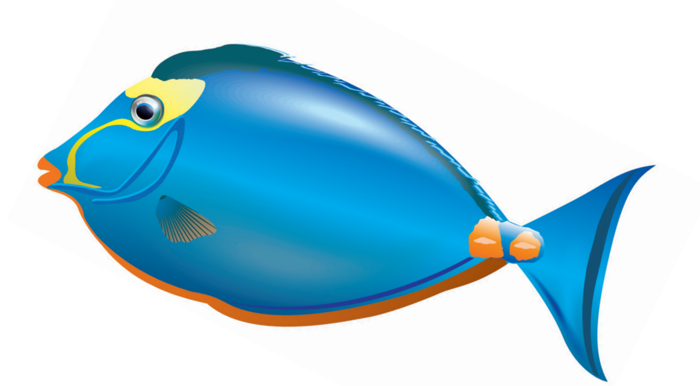
NOAA Resources

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:

• Interview with Papahanaumokuakea Marine National Monument Superintendent Aulani Wilhelm
http://www.earthsky.org/interviewpost/biodiversity/aulani-wilhelm-honors-wildlife-at-papahnaumokukea-national-monument
NMPS lessons "Game of Life" and "Empty Oceans" for grades 6-8
http://www.sanctuaries.noaa.gov/education/teachers/curriculum.html
• Ocean Service lessons "Get Smart," "The Stinging Sea," and "Fix It!" for grades 9-12
http://oceanservice.noaa.gov/education/classroom/welcome.html
• NOS Contaminants in the Environment:
http://oceanservice.noaa.gov/education/classroom/12_environcontam.html
• NOS Harmful Algal Blooms:
http://oceanservice.noaa.gov/education/classroom/07_algal.html
• NOS Natural Resource Restoration:
http://oceanservice.noaa.gov/education/classroom/08_restor.html
• NOAA Ocean Service Discovery Story Prince William's Oily Mess.
http://oceanservice.noaa.gov/education/stories/oilymess/welcome.html
• NOAA Ocean Service Lesson "Eyes on the Estuary" and "Getting Physical with Estuaries"
http://oceanservice.noaa.gov/education/classroom/14_nerrs.html
• NOAA Ocean Service Lessons "Do You Want to Risk It"
http://oceanservice.noaa.gov/education/classroom/15_hazardsassessment.html
• NOAA Ocean Service Lessons "The Stinging Sea" and "The Dead Zone"
http://oceanservice.noaa.gov/education/classroom/13_ecoforecasting.html
• NOAA Ocean Service Lesson "Where's the Point"
http://oceanservice.noaa.gov/education/classroom/09_coast_manag.html
• NOAA Ocean Service Estuaries Discovery Kit Web Pages "Why are Estuaries Important? The Economy and the Environment" http://oceanservice.noaa.gov/education/kits/estuaries/estuaries02_economy.html and "Ecosystem Services" http://oceanservice.noaa.gov/education/kits/estuaries/estuaries03_ecosystem.html and "Human Disturbances to Estuaries"
http://oceanservice.noaa.gov/education/kits/estuaries/estuaries09_humandisturb.html
http://oceanservice.noaa.gov/education/kits/corals/coral09_humanthreats.html
• Coral Literature, Education, and Outreach curriculum on coral bleaching and CO_2
http://www.coral.noaa.gov/cleo/education.shtml
•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



OCEAN LITERACY ESSENTIAL PRINCIPLES

2. The ocean and life in the ocean shape the features of the Earth.
   2c. Erosion- the wearing away of rock, soil and other biotic and abiotic earth materials- occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

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.
   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.
   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.
   6f. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change and storm surges).
   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: 2c. 5a. 5d. 5e. 5f. 6e. 6f. 6g.
Lesson 2: 6e. 6f. 6g.
Lesson 3: 5d. 5f. 6e. 6g.
Lesson 4: 5d. 5f. 6e.
Culminating: 5a. 5d. 5f. 6e. 6f. 6g.

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.

Lesson 1, 3, 4 and the Culminating Lesson: 3a.

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.