Education Kit

Navigating Change™

Northwestern Hawaiian Islands

PREL

STATE OF HAWAII
DEPARTMENT OF
EDUCATION

Department of Land and Natural Resources
Hawai'i, Earth's Best

NOAA

U.S. FISH & WILDLIFE SERVICE

BISHOP MUSEUM
CELEBRATING A CENTURY OF DISCOVERY

Navigating Change
Education Kit

Hokule'a brings stories of the Northwestern Hawaiian Islands to further examine the cultural and biological wonders of this unique and rarely seen ecosystem. Hokule'a is the messenger of lessons learned among the *kupuna* (older) islands. The goal of Navigating Change is to motivate, encourage and challenge people to take action to improve the environmental conditions in their own backyards, especially as it pertains to our coral reefs ecosystems. We want people to take responsibility for the stewardship and sustainability of our islands and our ocean.

Navigating Change is brought to you in partnership by: United States Fish and Wildlife, NOAA, Department of Land and Natural Resources, KidScience Hawaii Department of Education, Pacific Resources for Education and Learning (PREL), Bishop Museum

The Navigating Change Education Kit consists of the following:

Five video segments about Navigating Change.

1. **Navigating Change: The Voyage**
   To begin our journey we must know something about where we are going. The Hawaiian archipelago extends far beyond Kauai including a 1200 mile chain of coral islands, reefs and atolls. The voyaging canoe Hokule'a carries the messages from the Northwestern Hawaiian Islands to learn of its unique and spectacular cultural and natural elements. This pristine area is covered with life so numerous and vivid there are uncountable numbers of native seabirds, fish and coral that make it seem unreal. However, this place is very real and is apart our State of Hawai`i. With this voyage Hokule`a unveils not only a native healthy ecosystem but begins to reawaken a cultural journey back to those islands when Polynesian people once voyaged there some 1500 years ago.

2. **Navigating Change: Land to Sea Connections**
   The Northwestern Hawaiian Islands clearly illustrates how the life on land is connected to life in the sea. Seabirds, green sea turtles and Hawaiian monk seals need both a healthy land and a healthy sea in order to survive. In the NWHI it is easy to see how those two ecosystems are interrelated. Native Hawaiians understood how the land was connected to the sea as they saw our islands as a system of corridors extending from the mountains to the sea. To ensure and protect life in a healthy reef ecosystem, requires conserving resources from high in the mountains to low in the wetlands. Taking care of our `ahupua`a is critical to our health and well being so we can once again experience Hawai`i's native wildlife.

3. **Navigating Change: Change Over Time**
   The natural environment that surrounds seems so beautiful so it must be healthy, or is it? Gradually over time our natural resources have declined. The younger generation today is unaware of what a healthy ecosystem really is because what they see around them today they assume is okay. Through comparisons between the NWHI ecosystems and the main Hawaiian Islands can we visually see what type of declines have occurred in our own backyards. The NWHI offer a glimpse into the past. The NWHI give us an idea of what the main Hawaiian Islands once looked like and serve as a model of hope. How do we bring back a healthier Hawai`i? How do we stop this trend of decline?

4. **Navigating Change: Human Impacts**
   We live in a fragile place. Islands and reefs are devastated by invasive or alien species in our remote island home, a place naturally belonging to native plants and wildlife that live nowhere else on the planet. Our oceans have become dumping grounds where debris can drift for years finally ending up on our Hawai`i by the tons. The good news is that we can learn from our mistakes. The restoration work occurring in the NWHI can be an inspiration for changing the way we live in the main Hawaiian Islands. We can learn to interact with our environment in healthy ways. These ways give value and a quality of life for us as humans so we can experience the true native beauty and essence of Hawai`i.

5. **Navigating Change: You Make the Difference**
   Hokule'a's messages from the NWHI has shown us that the NWHI are indeed an incredible place. These islands have given us an opportunity to see how we can live better and how we must accept responsibility to malama, to care for our island home if we don't want to destroy our environment and ultimately our well being. We have learned how easily humans can leave their mark and with hard work we can restore native wildlife to our own backyards. We can instill a responsibility to malama, to care for our island home. Students and communities can have fun by taking action and ultimately knowing they truly are responsible for their own `ahupua`a and even doing just a little at a time can make a HUGE difference.

   Videos available:
   - On the web: hawaiianatolls.org
   - Videos to be broadcast on Educational Access Channels, Hawaii DOE TV
     10/6 at 2:00 p.m. and on 10/13, 10/20 and 10/27 at 9:00 a.m. and 2:00 p.m.....Set VCR"s and tape them!!!!!!
   - DOE teachers can request the videos from the Television Services Office
     http://www.teleschool.k12.hi.us
   - Private schools, please call 397-2405 for information about obtaining copies.

Curriculum Package

The accompanying lessons and activities support the videos.

- Where in the World are the Northwestern Hawaiian Islands?
- Compare and Contrast
- Shifting Baselines
- Coral Reef Habitats
- From Land to Sea
- Did You Know???
- Human Impacts on the Reef
- Who Makes the Decisions? (A Town Meeting)
- Getting Involved
- Sail Away
- Wayfinding: Navigating Using Environmental Clues

Navigating Change Educational Kit

Unit at a Glance:

What lessons are there to be learned from the Northwestern Hawaiian Islands? Students will take a journey up to the Northwestern Hawaiian Islands where the green sea turtles, awesome monk seals and millions of sea birds come to nest and give birth. Why do they migrate to these remote islands? What is the connection between the islands and the sea? How are these islands different from the main Hawaiian Islands? Can we "navigate change" to help improve the environmental conditions in our own backyards?

Standards and Performance Indicators

Standard	Performance Indicators
Domain I **Standard 3: Using Unifying Concepts and Themes** Students use concepts and themes such as system, change and scale to model and to help them understand and explain the natural world.	• System: Observes and describes how parts influence each other in a system. • Change: Identifies patterns of change in things, using data and evidence.
Domain II **Standard 3: Malama Ika'Aina: Sustainability** Students make decisions needed to sustain life on earth now and for the future generations by considering the limited resources.	Conservation of resources: • Identify natural resources • Develop a way to conserve each resource. • What so people believe/assume about the existence of natural resources?
Domain II **Standard 5: Interdependence** Students describe, analyze and give examples of how organisms are dependent on one another and their environments.	• Explains how organisms respond to a constantly changing environment. • Explains how changes in a specific niche affect the population of organisms living there.
Domain II **Standard 19:Forces That Shape the Earth** Students analyze the scientific view of how the Earth's surface is formed.	• Gives examples of how wind, waves and water shape and reshape the Earth's land surface.

CULMINATING ACTIVITY

Students are to identify and gather information about an environmental issue in their community. Students will then write a newspaper to create awareness of the issue. This newspaper needs to include the following types of stories:

- front page story
- editorials, both for and against the issue
- business story, what impact is this issue having on the economy
- political cartoon
- want ad

The content of the stories need to focus on the environmental issue. Students may need to take a look at a real newspaper for ideas on how to write their stories.

Student Activities

- Where in the World are the Northwestern Hawaiian Islands?
- Compare and Contrast
- Shifting Baselines
- Coral Reef Habitats
- From Land to Sea
- Did You Know???
- Human Impacts on the Reef
- Who Makes the Decisions? (A Town Meeting)
- Getting Involved
- Sail Away
- Wayfinding: Navigating Using Environmental Clues

Culminating Project Rubric

Students are to identify and gather information about an environmental issue in their community. Students will then write a newspaper to create awareness of the issue. This newspaper needs to include the following types of stories:

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	Advanced 4	**Proficient 3**	**Basic 2**	**In-Progress 1**	**Score**
Collecting Data	Describe the issue. Explain who/what is impacted and how.	Describes the issue or problem.	Identifies issue or problem.	Picks a topic	
Organizing Information	Outline information for each story.	Outline the information	Identify topics List facts	Identify topics	
Analyze Information	Gives pros and cons and suggestions of a solution.	Gives pros and cons of the issue.	Explains one side of the issue	Identifies topic	
Final Product	Completes the stories into a newspaper format, include pictures.	Writes the 5 different types of stories.	Writes the front page story.	Can verbally describe the issue.	
				Total Score	

Standards and Performance Indicators

Standard	Performance Indicators	Student Activity	Completed
Domain I **Standard 3: Using Unifying Concepts and Themes** Students use concepts and themes such as system, change and scale to model and to help them understand and explain the natural world.	• System: Observes and describes how parts influence each other in a system. • Change: Identifies patterns of change in things, using data and evidence.	• Land to Sea • Shifting Baselines	
Domain II **Standard 3: Malama Ika'Aina: Sustainability** Students make decisions needed to sustain life on earth now and for the future generations by considering the limited resources.	Conservation of resources: • Identify natural resources • Develop a way to conserve each resource. • What so people believe/assume about the existence of natural resources?	• Compare and Contrast • Human Impacts on the Reef • Did You Know? • Who Makes Decisions? • Getting Involved	
Domain II **Standard 5: Interdependence** Students describe, analyze and give examples of how organisms are dependent on one another and their environments.	• Explains how organisms respond to a constantly changing environment. • Explains how changes in a specific niche affect the population of organisms living there.	• Coral Reef Habitats • Land to Sea	
Domain II **Standard 19:Forces That Shape the Earth** Students analyze the scientific view of how the Earth's surface is formed.	• Gives examples of how wind, waves and water shape and reshape the Earth's land surface.	• Where in the World are the Northwestern Hawaiian Islands?	

Where in the World are the Northwestern Hawaiian Islands?

Lesson at a Glance

Students will create a model that explains where the Northwestern Hawaiian Islands are located and what they islands look like.

Objectives

Students will be able to:

- Locate and name all of the Hawaiian Islands.
- Describe the characteristics of each island.
- Explain what kind of islands they are.

Background Information

The Northwestern Hawaiian Islands are an archipelago or island chain that stretches 1,200 miles northwest of the main Hawaiian Islands. These 10 islands vary from islands made of high rocky cliffs to low islands, to sandy atolls. Millions of sea birds, monk seals and the green sea turtles are dependent upon these islands and surrounding reefs. These islands cover over 11,000 square kilometers of coral reef habitat and represent over 70% of all coral reefs found in the world.

The Hawaiian Islands are part of a long line of underwater volcanoes. A hotspot located under the oceanic plate spews out hot molten rock, creating a volcano. These undersea volcanoes eventually reached the surface of the ocean creating islands. These islands continue to grow as long as the lava continues to flow. The Pacific Plate moves slowly over the hotspot creating new islands. These volcanic islands are slowly sinking and eroding away. Eventually these high rock islands become atolls, or rings of coral. The Northwestern Hawaiian Islands includes 3 types of islands: Nihoa, Necker and Gardner Pinnacles are volcanic basalt cliffs, Laysan and Lisianski are coral islands with fringing reefs, and French Frigate Shoals, Maro Reef and Hermosa , Midway and Kure are atolls.

Materials Needed

- Map of the Hawaiian Islands Archipelago (includes main and Northwestern Hawaiian Islands)
- Fact sheets on each of the Northwestern Hawaiian Islands.
- Rulers/pencils and colored pens.
- Materials for creating maps or models. See student activities below for ideas.
- Access to computers if possible to have students to research the islands.

Student Activity:

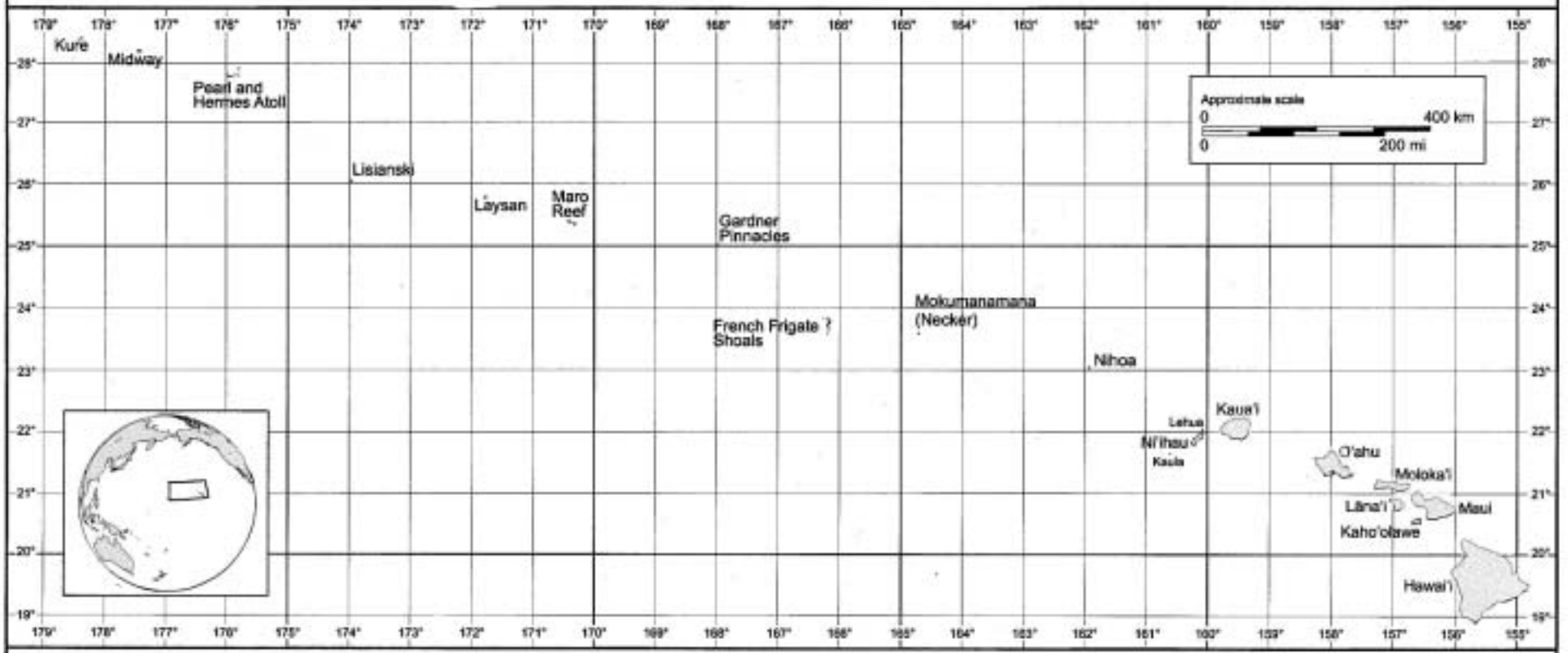
Listed below are suggestions of mapping activities. The term Hawaiian Islands refers to the main and northwestern Hawaiian Islands. The following islands need to be included: Hawaii, Kahoolawe, Maui, Lanai, Molokai, Oahu, Kauai, Niihau, Nihoa, Mokumanamana, French Frigate Shoals, Gardner Pinnacles, Maro Reef, Laysan, Lisianski, Pearl and Hermes, Midway Atoll, Kure Atoll.

1. **3-D Map of the Islands.**
   Give students a copy of the Hawaiian Islands Archipelago map, to use as reference and copies of the island descriptions for information about the islands. Use clay, paper mache, or anything else the students come up with to create models of the Hawaiian Islands. Include on this model the edges of North America, Asia, Australia and the South Pole.

2. **Mapping the Hawaiian Islands**
   Give students the map of the Hawaiian Island Archipelago to use as a reference. Give each pair or group of students a desk size piece of paper. Students are to figure out how to create a map of the Hawaiian Islands to scale. Challenge them to figure out how to use the latitude and longitude to replicate the map. Give the students copies of the Island descriptions. Have them draw an image of what each island looks like color it and cut them out. Locate where the islands belong, paste the islands on the map and name them. Indicate also on this map North America, Asia, Australia and the South Pole.

3. **Create a Class Bulletin Board Map.**
   Assign each group of students a different island. Have them research the islands and make a poster of the island. They are to include the physical characteristics, flora and fauna and any interesting facts they can find about their island. Include surrounding reefs and any sea animals found primarily on/or around the island Place the island posters on the bulletin board in the appropriate positions. Students may want to check out the following web sites for more information.
   - Navigatingchange.org
   - Hawaiianatolls.org
   - PVS-Hawaii.com

Northwestern Hawaiian Islands



Navigating Change
Northwestern Hawaiian Islands

www.navigatingchange.org

PEARL AND HERMES ATOLL

Pearl and Hermes Atoll is a classic atoll that is primarily underwater and has numerous islets, seven of which are above sea level. The protective perimeter reef encircles all but the northwestern quadrant of the lagoon. Numerous small low coral islets are located behind the perimeter reef. While total land area is only 0.36 square km (80 acres), the reef area is huge, over 450 square miles (194,000 acres). The atoll is ever-changing, with islets emerging and subsiding.

Presently, about 160,000 birds from 22 species are seen. They include Black-footed albatrosses, Tristram's storm petrels, and one of two recorded Hawaiian nest sites of Little terns. Endangered Laysan Finch eke out a living on the tiny islands where they were translocated in the 1960's. They were introduced in an attempt to establish a "back-up" population.

The sandbar islets support coastal dry grasses, vines, and herbal plants, including 13 native species and 7 introduced species. The plants survive because they are salt-tolerant and able to recover from frequent flooding events.

Hawaiian monk seals and sea turtles breed and feed at Pearl and Hermes, and it is a mating area for spinner dolphins. The atoll has the highest standing stock of fish and the highest number of fish species in the NWHI. These include saber squirrelfish, eels, Galapagos sharks, sandbar sharks, ulua (big jacks), angelfish, aweoweo, uhu, and numerous lobsters. Hiding between the unique reef and lagoons are very unusual invertebrate habitats. For example, several sponges collected recently may be new to science!

Black-lipped pearl oysters, at one time very common, were harvested in the late 1920s to make buttons from their shells. Over-harvested, the oysters were nearly eliminated, and today only a handful remain even long after their harvesting was declared illegal in 1929.

NIHOA ISLAND

Nihoa is unlike any of the other Northwestern Hawaiian Islands (NWHI) with its 900 foot cliffs, basalt rock surface, and tiny beach. This island is about 1 square km (171 acres) and is at the southeastern end of the NWHI chain.

Although difficult to imagine today, this remote land of rugged cliffs and steep valleys provided a home for Hawaiians between A.D. 1000 and A.D. 1700. More than 80 cultural sites are known, including habitation terraces and bluff shelters, religious places, agricultural terraces, and burial caves. Many of the mea makamae (cultural objects) and structures associated with these wahi pana (cultural places) are similar to many found throughout the Main Hawaiian Islands. It is believed that the abundance of natural resources and at least three freshwater seeps may have supported as many as 175 people between A.D. 1000 and A.D. 1700.

The island's rugged landscape may seem uninhabitable from a distance but the very essence of Nihoa is life, a treasure chest of species found nowhere else in the world. Niches in rocky outcroppings support some of the most unique and varied insect, seabird, and plant life of all the NWHI.

Seventy-two terrestrial arthropods including giant crickets and earwigs, and two endemic landbirds, the Nihoa finch and Nihoa millerbird, are found only on Nihoa. Native endangered plants include a loulu or fan palm and 'ohai shrub.

Basalt underlies most shallow water habitats surrounding Nihoa. Limu (algae), wana (sea urchin), and opihi (limpet) inhabit these shallow waters, while sharks and jacks hover in deeper waters offshore.

In order to protect the island's fragile ecosystem, few visitors are allowed on Nihoa and strict protocols are required. Approval must be given by the U.S. Fish and Wildlife Service and is mostly granted to those doing cultural and scientific research.

MOKUMANAMANA (NECKER ISLAND)

About 155 miles northwest of Nihoa lies Mokumanamana, a small basalt island that is 1/6 square km, or 46 acres, in size. It is about one-quarter the size of Nihoa. Although the island is the second smallest of the NWHI, it has the second largest surrounding marine habitat (almost 385,000 acres). Large offshore areas include Shark Bay on the north side, West Cove and Northwest Cape as well as miles of shallow reef to the southeast. Island shorelines are generally steep around all sides except the east, where a shallow, wave-planed basalt shelf fills Shark Bay. West Cove, in the lee of the prevailing winds, affords the only semi-protected shallow submerged habitat off the island.

Necker Island's small size and steep topography explain its relatively small number of plant species, but all except one of the six species are indigenous and hosts a all exclusive native plant community. No non-native or alien species are allowed!

Sixteen of the seabird species typical of the NWHI nest at Necker, but the species favor cliff nesting sites (White Terns, Black Noddies, and Blue-grey Noddies) are particularly numerous there. The terrestrial life encompasses 15 endemic (found only on that island) insects such as wolf spiders and bird ticks.

Marine life includes gray reef sharks and manta rays. Hawaiian monk seals are seen on the island's rocky shores. A great abundance and diversity of sea cucumbers, sea urchins, and lobsters are found in Shark Bay. Little coral life exists in the shallow areas due to the constant wave action that scours the underwater basalt. Most reef life is found in holes and elevated areas protected from the currents. Below the shallow reef are extensive deeper "shelves" that extend many miles from the island, especially to the southeast. These broad offshore areas are used for commercial fishing.

Mokumanamana is known for its numerous religious sites and artifacts. Fifty-two sites have been found that appear to have been used mainly for worship. Since the island seems to be too small and dry for living, with poor soil for farming, archaeologists believe that the religious sites were probably used by Hawaiians. They visited from nearby Nihoa and other islands but didn't stay.

MIDWAY ATOLL

Midway, the best known Northwestern Hawaiian Island (NWHI), is a circular-shaped atoll with three small islets (Sand, Eastern, and Spit) on the southern end of the lagoon. While its land area is small, about 1,535 acres, the atoll has approximately 87,000 acres of reef area.

The atoll was designated as the National Memorial to the Battle of Midway in 2000. Today, many buildings and houses still exist from when it was an active Naval Base.

Today a fulltime Refuge staff administers a small visitor program, cares for its wildlife, restores native plant life, and protects historic resources.

Nearly two million birds of 19 species nest on Midway. The atoll has the largest Laysan albatross colony in the world. Other birds include black-footed albatross, red-tailed tropicbirds, white terns, black and brown noddies, shearwaters, and hundreds of thousands of Bonin petrels. One of the rarest is the endangered short-tailed albatross.

Three-fourths of Midway's plant species were introduced. These include weeds, ornamental shrubs, exotic vegetables, and trees such as coconut palms and ironwood. Major efforts are underway to control alien species and restore native habitats.

The waters abound with spinner dolphins, monk seals, and green sea turtles. More than 250 species of fish live in its waters, including the rare Hawaiian grouper (hapu`upu`u), jack (ulua), goatfish (kumu), and sharks. Beyond the reefs are pelagic fishes such as tuna and marlin.

Despite 100 years of human impact, the reef at Midway is rich and diverse. Sixteen species of stony coral have been reported, and scientists believe there may be many more. Marine habitats, including spurs, grooves, and sand channels, are home to several algaes, seagrass meadows, urchins, bi-valve clams, sponges and more.

MARO REEF

Maro Reef is the largest coral reef in the Northwestern Hawaiian Islands (NWHI), with over 1500 square km (approximately 600 square miles or 478,000 acres) of reef area. Unlike the classic ring-shaped atoll, Maro is a complex maze of linear reefs that radiate out from the center like the spokes of a wheel. A few large reef blocks cast up on the shallow northeastern reef crest can be sticking up out of the water, but are constantly washed over by wave action. Maro lacks any protective perimeter reef leaving this network of linear, patch and pinnacle reefs exposed to wave action from any direction.

Marine habitats of Maro Reef range from sandy lagoons to steep reef slopes, large coral heads, ocean pinnacles, and patch reefs. Gaps in the reef cause waves to sweep into the lagoon clouding some areas with silt and sand.

Despite its turbid water conditions which creates difficult study conditions, scientists have seen a greater abundance and diversity of coral here than most any other reef system in the NWHI chain. Many areas of the reef, particularly on the west side, have a large number of coral species, including *Montipora capitata* and finger coral *Porites compressa* that grow abundantly on the reef slopes. Maro Reef has a large amount of the hard, pink crusty algae that grows on coral called "coralline algae" that acts like cement and holds the coral together in high surf. The reefs support numerous butterflyfish and surgeonfish species. Large ulua and omilu have been seen in the reef's open waters, along with white-tip and grey reef sharks.

Some researchers believe that, while Maro Reef has very healthy reefs, it may be "on the verge of drowning" because the reefs are narrow, unconnected, and unprotected from storm waves. Others feel that the abundance and health of the corals suggest that Maro Reef will survive as a healthy reef.

LAYSAN ISLAND

Laysan is the second largest land mass in NWHI (1,015 acres), about 1 mile wide and 1-1/2 miles long and shaped like a poi board. It was formed from geologic forces pushing upward and by coral growth. It has fringing reefs and a hypersaline (very salty) lake in the middle of the island, the only lake in the island chain.

Surrounding the lake, the beautiful encircling white sand beach is topped by dry coastal grasses. Sedges grow thick near the lake's edge. Over 30 kinds of plants live on Laysan. In addition to the koloa, the Laysan duck is Hawai`i's "other" native duck species. This striking endemic duck has developed a fascinating eating habit: it runs on mud flats while snapping at swarms of brine flies to retrieve its meal.

Laysan has the fullest complement of all the bird species in the NWHI. Huge populations of seabirds nest and migratory shorebirds visit including Black-footed and Laysan albatross, Christmas and wedge-tailed shearwaters, and bristle-thighed curlews. Following the devegetation caused by rabbits, several land birds became extinct including the Laysan honeycreeper and millerbird, but two endemic land birds remain -- the hardy Laysan finch and Laysan duck. Of the 75 native invertebrate species found on Laysan, 15 are endemic.

Although the reef at Laysan is the smallest of the NWHI (145,334 acres), it is quite rich. Numerous sea turtles and monk seals appear on the island. Several species of Hawaiian surgeonfish and large schools of convict tangs are in the shallow, wave-washed waters around the island. Twenty-seven species of stony coral are reported, and branching corals are common.

Although a host of introduced species changed the "original fabric" of the island's ecology, this place has benefited from years of effort to "malama" (take care of) the island. The U.S. Fish and Wildlife Service set up a remote island camp in 1991 and have eliminated weeds and restored native vegetation. As a result, finch and duck populations are increasing. Laysan, the poster child for restorative island efforts, is considered one of the "crown jewels" of the NWHI.

KURE ATOLL

Kure Atoll is the most remote of the Northwest Hawaiian Islands, and the northernmost coral atoll in the world. Kure is a pronounced oval shaped atoll, which is 10 km at its maximum diameter and 91 km west-northwest of Midway Atoll at the extreme northwest end of the Hawaiian archipelago. Green Island (105 hectares) is the only permanent island in the atoll. Sand Island is a large sand bar system which varies in size with the seasons. The maximum elevation on Green Island is 8 meters.

In the 1960s, the U.S. government built a loran (navigation) station and a runway on Green Island, an islet of Kure. The loran station was later closed, after which the island was cleaned up and the tower and most of these structures taken down. Today, State employees live and work seasonally out of the remaining bunker type structures.

Despite its northern location and relatively cool waters, the aquatic habitats of Kure provide a diversity of corals and large invertebrates such as echinoderms, crustacea and mollusks. The turquoise waters of the lagoon and near-shore reefs support large schools of dolphins, jacks, sharks, goatfish, and chub, as well as dragon eels, knifejaws, masked angelfish and rare native grouper. Recent aquatic surveys have identified rare fish species and behaviors seldom seen in the main Hawaiian islands, raising additional questions about the effects of human activities on marine ecosystems.

The island is very important monk seal pupping area and s nesting area for shearwaters, petrels, tropicbirds, boobies, frigatebirds, albatrosses, terns and noddies. It is also a wintering area for a variety of migratory bird species from North America and Asia.

The atoll is lying at the gateway between the NWHI and the emperor seamounts.

GARDNER PINNACLES

When the two pinnacles of volcanic rock between French Frigate Shoals and Maro Reef come into view, mariners know they have reached Gardner Pinnacles. It is the last visible remnant of the chain's volcanic past.

Gardner Pinnacles is a collection of basalt pinnacles and emergent rocks. "Shorelines" are generally steep cliffs or ramps that descend steeply to depths of about 15m. A talus of large basalt slabs and block accumulate at the base of the pinnacles forming caves, rock piles and lean-tos that are important microhabitats for fish and invertebrates. Ledges and cliffs characterize the submerged base of the pinnacle and rocks above the talus.

This 5-acre island, with the smallest land area of any Northwestern Hawaiian Islands (NWHI), has 1,904 square kilometers (604,600 acres) of underwater shelves that extend out from the pinnacles, the most of any island or bank in the NWHI.

The pinnacles were first reported by Captain Joseph Allen of the Nantucket whaler, *Maro,* on June 2, 1820. He reported seeing "a new island or rock not laid down on any of our charts... it has two detached humps....we call it Gardner's Island."

Today, Gardner is known for its abundance of giant opihi, the endemic Hawaiian limpet. The islands' rocky inter-tidal areas are an ideal habitat for opihi. Coral species of many varieties are distributed throughout the pinnacles' reef system. Acropora table corals have been noted on the leeward side, while tube, stony, and soft corals have been found throughout the reef. Gardner Pinnacles' waters hold one of the highest numbers of fish species in the NWHI, including the red lip parrotfish, the doublebar goatfish, and the reef triggerfish.

Gardner is home to seabirds, insects, and only one species of plant, the succulent sea purslane (Portulaca). Scientists have observed 19 species of seabirds, 12 of which breed on the steep cliffs, including the rare blue gray noddy. Two species of migratory shorebirds, the ruddy turnstone and golden plover often stop over to rest or feed here as commonly noted on all the NWHI.

Despite its small size and isolation, the island has a surprisingly wide array of insects. Spiders, mites, moths, centipedes, flies, beetles, isopods and earwigs, among others, have been found on Gardner.

FRENCH FRIGATE SHOALS

French Frigate Shoals (FFS) is the largest atoll in Hawaii, consisting of a large, crescent-shaped reef. FFS is a good example of a classic atoll, formed on top of a volcano now submerged after millions of years of erosion, and surrounded by a well-developed coral reef. Numerous small, coral islets are found in the lagoon. In the northwestern section of the lagoon is a unique rock formation, a steep-sided tall basalt pinnacle (La Perouse) that juts out of the water and is the last remnant of the original volcano. While the land area is only ¾ square kilometer (67 acres), the total coral reef area of the shoals is over 744 square kilometers (232,000 acres). Marine habitats vary from exposed ocean-facing reefs to protected pockets surround by shallow linear reefs.

The shoals were used by the military during World War II. Tern Island, a part of the atoll, was formed into a runway to serve as a refueling stop for planes en route to Midway. From the air Tern Island looks like the shape of an aircraft carrier. The original seawall, runway, and some of the building structures remain on Tern Island and the U.S. Fish and Wildlife Service continues to maintain a field station there staffed year-round by two permanent employees and a handful of volunteers.

The FFS reef system supports the greatest variety of coral species in the NWHI, including the acropora table coral, finger coral, and stony coral. More than 600 species of invertebrates such as sponges, coral worms, snails, lobster, crabs, shrimp clams, oysters, sea urchins, and sea stars are found at FFS, including many endemic species. One area of the reef consists almost entirely of bivalve clams. More than 150 species of algae live among the reefs, including red, green and brown algae. The outer reef waters support gray reef sharks, butterfly fish, and large schools of jacks and groupers.

FFS also nurtures charismatic megafauna -- the green sea turtles and Hawaiian monk seals. More than 90% of the Hawaiian population of threatened green sea turtles, travel to the FFS for safe nesting. Satellite tagging of these turtles has indicated that most of them migrate to the Main Hawaiian Islands to feed and then return to breed at FFS. Some turtles travel northwest to feed, and others have traveled as far south as Johnston Atoll. The many small islets of FFS also attract the largest number of endangered Hawaiian monk seals in the NWHI. It is "their" place of refuge.

Compare and Contrast

Lesson at a Glance

Students will observe video segments on the Main Hawaiian Islands and the Northwestern Hawaiian Islands and will list comparisons (similarities) and contrasts (differences). This activity should continue throughout the unit.

Objectives

Students will be able to:

- List comparisons and contrasts between the Main Hawaiian Islands and the Northwestern Hawaiian Islands.
- Create a poster or display that shares the comparisons (similarities) and contrasts (differences).

Background Information

Navigating Change is intended to motivate, encourage and challenge people to take action to improve the environmental conditions in their own backyards, especially as it pertains to our coral reefs. The voyaging canoe Hokule'a will sail to the Northwestern Hawaiian Islands and serve as the messenger of what the Northwestern Hawaiian Islands (NWHI) can tell us. Stories, comparisons, and lessons from the NWHI and the Hokule'a will tell us how to better *malama* (take care) of our island home.

The *KidScience* series and the Navigating Change Education Kit shares with students the state of the Main Hawaiian Islands and the Northwestern Hawaiian Islands. Both include awesome video footage of both environments. Students are going to be asked to do some brainstorming about how and why they are different and/or similar.

Materials Needed

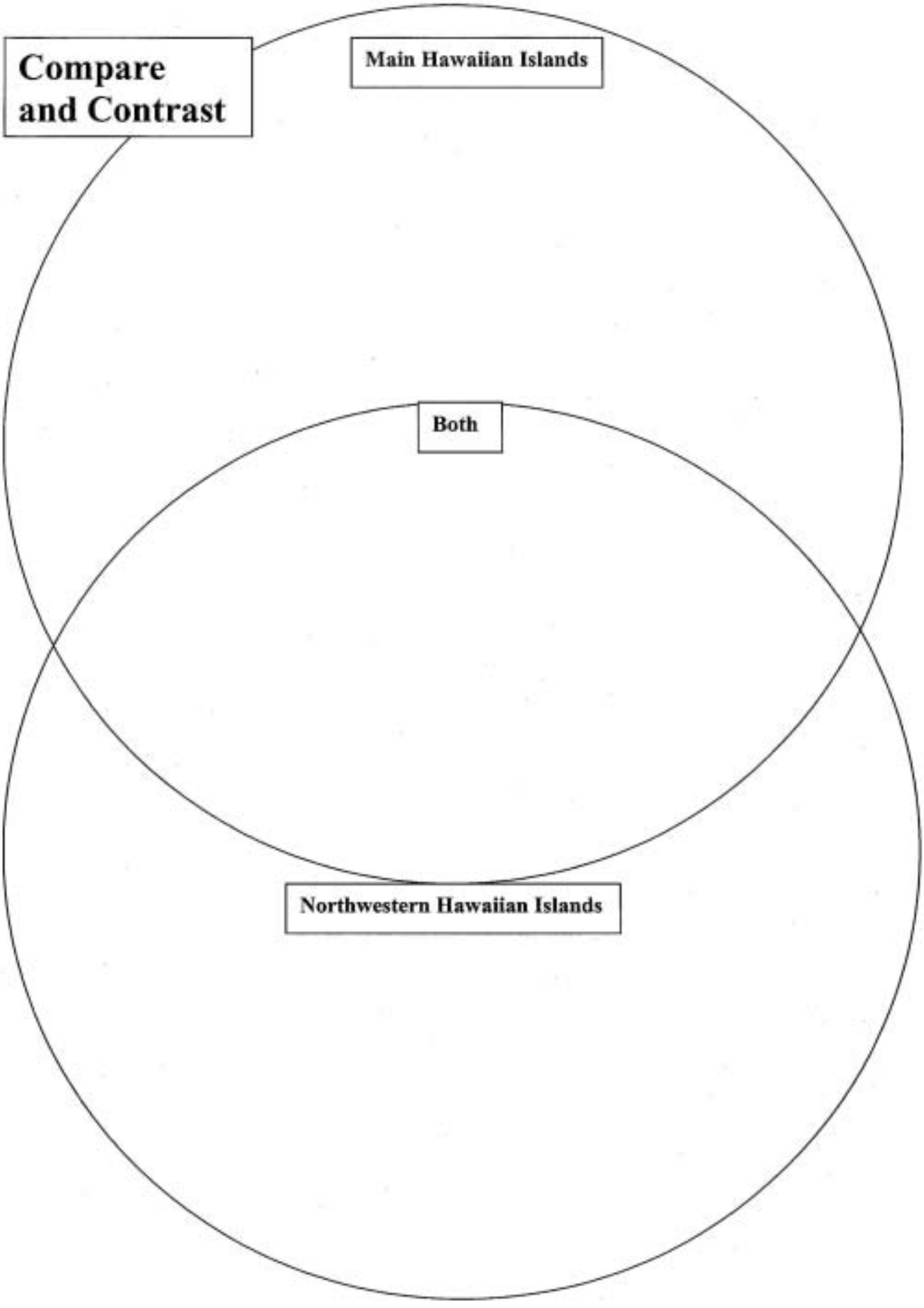
- Compare and Contrast diagram
- Poster size paper and colored pens

Student Activities

Provide opportunities for students to watch the KidScience series and/or the videos found in the Navigating Change Educator's Kit. Discuss as a class a few things that you could find in both the Main Hawaiian Islands and the Northwestern Hawaiian Islands and things that are different about them. Have the students list all the similarities and differences on a venn diagram. Encourage them to add to this diagram throughout the unit. Encourage them to do some research on the internet.

1. Students are to make a poster or display that shares the similarities and differences between the Main Hawaiian Islands and the Northwestern Hawaiian Islands. Encourage them to be creative.

Compare and Contrast



Shifting Baselines

Lesson at a Glance

The way we live, the things we do and the places that we live have changed drastically over the years. We need to know what the past like to be able to understand what kinds of changes are happening today.

Objectives

Students will

- Interview an elder in the community to learn about the past.
- Design and carry out a baseline study.

Background Information

A baseline is a reference point for measuring what changes have happened. Shifting baselines are the changes you see in something. An example of this might be the soccer team at the beginning of the season. The baseline would be what they were able to do at the beginning of the season, and the shifting baseline would be how they performed by the end of the season. In the science field it is a way of studying what is happening to an ecosystem. In order to know if and what are the changes, we need to know what it was like in the beginning. To be able to understand what changes have occurred over the years both on our land and sea ecosystems we need to know what the baseline is, what it was like in the beginning. Check out the shifting baselines.org website for more information.

Materials Needed

- Paper and Pencils

Student Activities

1. Learning From the Past
   Have students find a Grandparent or an elderly neighbor or friend to interview. Students are to ask them questions about a specific ecosystem. This could be the reef, a beach, a mountain, or valley. What was it like when they were young? Students then need to visit the same place and see what it is like today. Students are to find a

way to share this information. This could be a story, a chart, or a picture.

2. **Baseline Studies**

Find a site that the students would like to study. Have them figure out how to do a baseline study. Students need to chart or map the area, recording everything that is there. A real baseline study needs to go on for years, but have your students go back every so often to chart or map the area again. What has changed? Why do you think this has happened?

Coral Reef Habitats

Lesson at a Glance

Students will create/compare and contrast models of reef habitats found in the Northwestern Hawaiian Islands and the main Hawaiian Islands.

Objectives

Students will be able to:

- Describe different coral reef habitats
- Build models of reef habitats.

Background Information

Three hundred years ago, scientists thought corals were plants. They didn't seem to move around. They were more common in clear, sunlit waters. And, many of them grew into shapes reminiscent of bushes or trees. Today we know that corals are amazing animals. The coral that make up an important part of the solid structure of our reefs are actually colonies of thousands of individual animals that are connected to each other, and that build a framework to live in by extracting minerals from seawater. In this way they provide places to live for thousands of other kinds of reef organisms.

Corals are soft-bodied animals that share a similar body plan with their close relatives, jellyfish and sea anemones. Each of these animals has a sac-like gut with a single opening (the mouth0 surrounded by a ring of tentacles. Imbedded in these tentacles are hundreds or thousands of tiny stinging cells that are used for defense and to capture prey. If the animal can use its body to swim around in the water (e.g. jellyfish0 it is called a medusae, if the animal lives attached to the bottom (e.g. sea anemones) or to skeleton created by a colony (e.g.corals), then the individual animals are called polyps.

Most coral polyps are tiny animals, roughly the size of a grain of rice. But when many thousands of polyps are growing together in a colony, they can reach the size of a car. When many colonies grow next to and on top of each other, together with the algae and other organisms that make shells and skeletons that build up over time, the result is a coral reef.

Many corals have more than one way of getting the food they need to grow. With their stinger-lined tentacles, coral can capture tiny animals that drift by in the currents. This plankton includes tiny crustaceans and mollusks that you could barely see without a microscope, as well as the eggs and larvae of reef creatures. Corals also get food from a type of single celled algae that lives inside their tissues. These algae are called zooxanthellae and they have a symbiotic relationship with reef-building corals. Zooxanthellae use the energy from sunlight to convert water and carbon dioxide into sugar. The zooxanthellae use some of that sugar themselves, but much of it is available for use by the coral polyps that the algae are living in.

Corals come in many different shapes and sizes and have been given names like Brain coral, Elkhorn coral and Mushroom coral.

Reef building corals require certain water conditions in order to live and grow. These include water that is warm, clear and with salt content near the ocean average.

Materials Needed:

- Desk Size paper or bulletin Board
- Materials for creating corals. These could be made form pens and crayons or 3-D models.
- Materials for creating fish. (various types and colors of paper, pens, crayons etc)
- Pop-Up Reef worksheet
- Who am I? worksheet
- Fish Clues and Fish Colors worksheets.

Student Activities

This is a project for individual students, small groups or could be a class activity. The object is to create a coral reef ecosystem. This needs to include corals, algae, and animals you might find in a coral reef.

1. **Create a Reef**

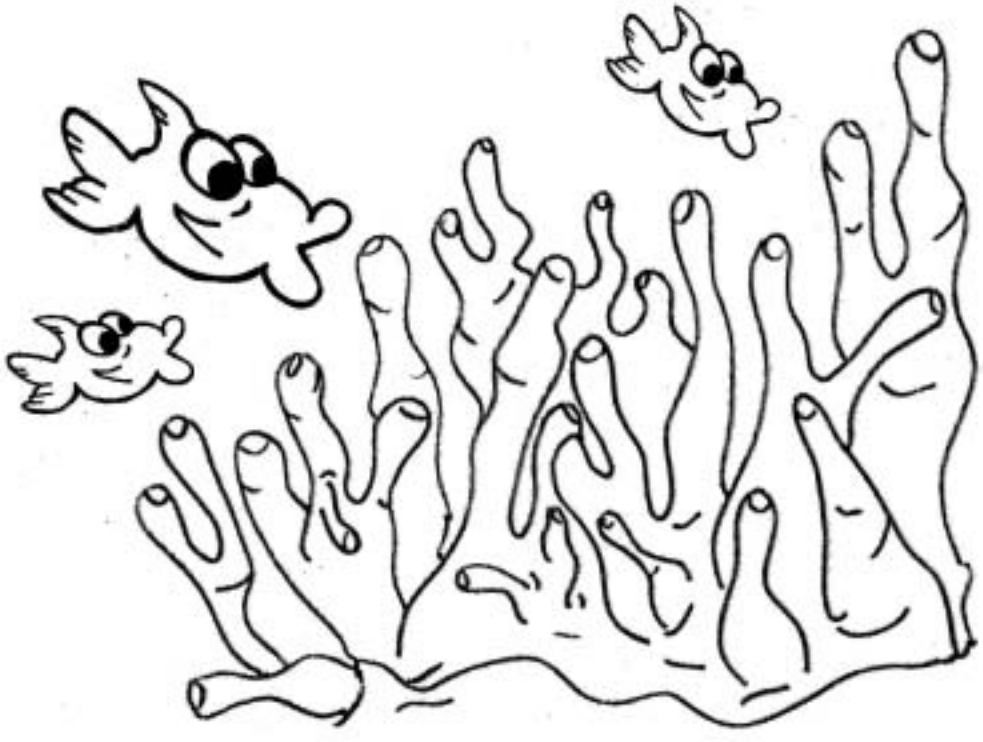
   Encourage students to make 2 separate models of reef ecosystems, one found in the Northwestern Hawaiian Islands and one from the main Hawaiian Islands. They need to start by doing some brainstorming of what they might find on these reefs. The videos will give them some

information. They may also want to check out the hawaiianatolls.org website and the Waikiki Aquarium's website for more information.

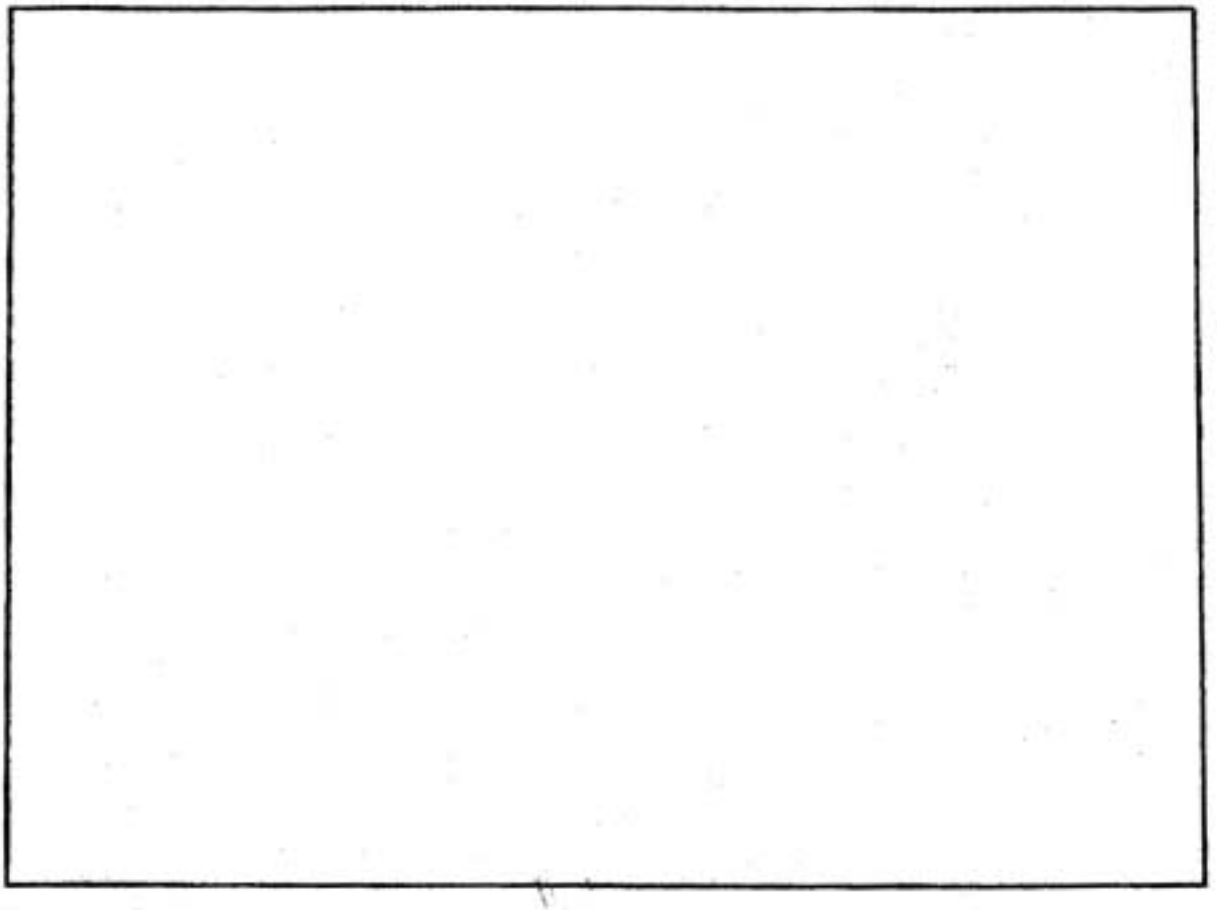
These models could be a poster, a bulletin board or a 3-D model. They need to include different types of corals, algae and different kinds of animals. Good line drawings of some of the corals and animals can be found on the kidscience.net website. Go to Kidstuff, then the Reef Detectives, then the Reef Critters.

Have students write about how the 2 different reef ecosystems and similar and how they are different. List things that might have caused the changes. List ideas of what can be done to protect the reef.

2. **Pop-Up Reef**.....see the attached worksheet for directions.
3. **Who am I?**....see the attached worksheet for directions.
4. **Fish Clues and Fish Colors**....see the attached worksheet for directions.



WHO AM I?



Pick a reef animal. Research its habits and environment. Draw a picture of the animal in the box.

I live _____ (where).

I prefer _____ (conditions).

I am made of _____ (structure).

I have _____ (physical adaptations).

I eat _____ (diet).

I hunt/forage/feed _____ (when/where).

I live _____ (life span).

I reproduce _____ (how, how often).

I am threatened by _____ (predators, environmental hazards).

"Pop-up Reef"

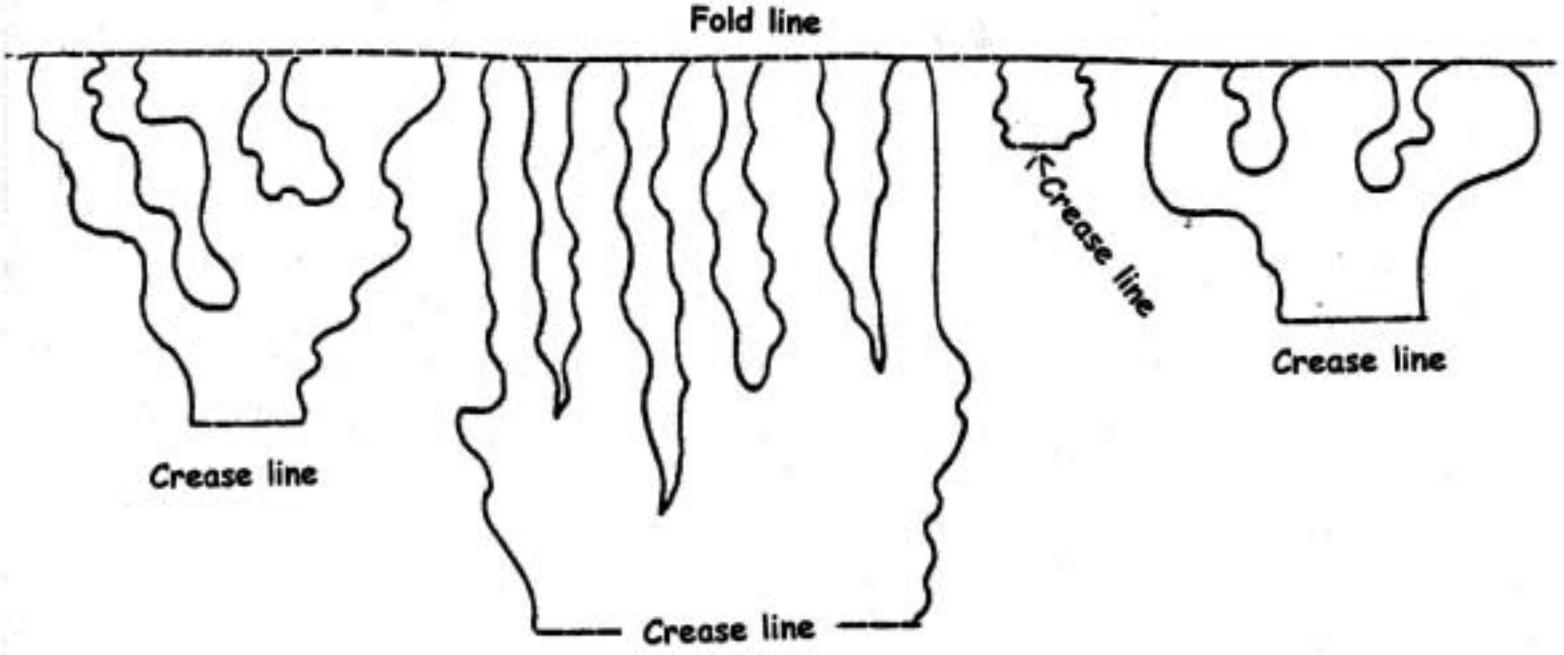
Materials Needed

- Reef pattern
- Construction paper/2 sheets of different colors
- Scissors
- Glue
- Colored construction paper to create reef critters

Directions

- Place the reef pattern on top of a piece of construction paper.
- Fold both on the center dotted line fold that goes across the paper.
- Cut through both pages on the solid lines.
- Open the construction paper reef up and pop the cut out reef sections forward. Crease on the dotted lines. Keep working on it....it will become a 3-dimentional reef.
- Glue the flat un-popped parts of the popped out reef to another piece of construction paper.
- Create reef critters and algae and add them to the popped out reef.

Pop-up Reef Pattern



"Fish Colors"

Fish can protect themselves by using protective coloration, advertising coloration or camouflage. Color the fish. Name a fish that fits each category.

Type of Coloration	Fish
Countershading The top of the fish is dark and the underside is white.	
False Eye Spots A dark spot is found on the tail end of the fish. It looks like an eye and confuses predators.	
Disruptive Coloring The color pattern on the fish alters the shape making it hard to recognize as a fish.	
Advertising Coloring Some fish have a color pattern on them that tells the rest of the fish that they are the "good guys". They eat the parasites off of other fish.	
Camouflage Camouflage is the ability to protect yourself by blending in with your surroundings.	

"Fish Clues"

The body shape and fins can tell you a lot about where the fish lives and how they move. Read the clues and draw the fish. Can you name a fish for each body shape?

Sphere These fish can puff their bodies out with air or water to make themselves too big to swallow.	
Compressed These fish are flattened from side to side, This makes them very thin and hard to see when viewed head on. The flattened body lets them dart in and out of the coral.	
Arrow Like Fish These are ambush hunters. They float motionless till prey comes by and then lunge out and grab them.	
Football Shaped This shape of tail enables them to be swift, powerful swimmers. They live in the open ocean.	
Flat-pancake-type-shape These slow swimming fish burrow into the sand to hide. They can camouflage themselves.	

CORAL

Coral are colonial invertebrate marine animals whose skeletons help to build up reefs. Corals are relatives of animals like jellyfish, but unlike them, corals are not free swimming. Coral reef ecosystems are some of the most productive, diverse, complex and beautiful places on earth.

Certain corals are called zooxanthellate corals, and are actually two creatures living together: a coral and a plant-like algae. Because the algae in zooxanthellate corals need light for photosynthesis, those corals are generally limited to shallow water environments less than 20 m (65 ft) deep.

The total number of coral species that live in the reefs of the Hawaiian Islands is relatively low. Scientists think that this is because of the isolation of the Hawaiian Islands. On the other hand, because of this isolation, a number of coral species live nowhere else on earth. Scientists estimate that more than 25% of the corals in Hawaiian waters are endemic.

The coral reefs of the Northwestern Hawaiian Islands (NWHI) encompass over 11,000 square kilometers of coral reef habitat, over 65 % of all coral reefs in the U.S. waters. The reefs are comprised of forty-seven species of hard coral and eight species of soft coral, a diversity that rivals the Main Hawaiian Islands.

Coral reefs are the foundation of an expansive ecosystem that hosts an interdependent association of vertebrates (i.e., monk seals, reef and bottom fish, turtles, birds, and sharks), invertebrates (i.e., corals, anemones, jellyfishes, mollusks, shrimps, crabs, lobsters, sea urchins, sea stars and sea cucumbers), sea grasses and algae.

Bishop Museum. (2002). *Life on Islands*. Join a Research Expedition to the Northwestern Hawaiian Islands. Retrieved May 22, 2002, from http://bishopmuseum.org/research/nwhi/biology.shtml

Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. (2002). *The Region: The Coral Reef Ecosystem*. Retrieved May 10, 2002, from http://www.hawaiireef.noaa.gov/region/region.html

Related Coral Sites:

Waikiki Aquarium http://waquarium.otted.hawaii.edu/
Hawaii Coral Reef Network http://www.coralreefnetwork.com/

ALGAE

Algae are photosynthetic organisms that can grow in a variety of places, ranging from hypersaline water to ocean water to freshwater. They vary from small, single-celled forms to complex multicellular forms, like kelps, seagrasses and seaweeds. In the Northwestern Hawaiian Islands, coralline algae is important in the formation of reefs. Many types of algae are used by humans for food (like the limu kohu, above), medicine and other products.

Algae are important as primary producers at the base of the food chain. Hawaiian Green Sea Turtles, for example, spend a lot of time gliding over the reefs, browsing on the seaweeds and algae there.

Algae also provide oxygen for other aquatic life. Unfortunately, with pollution or other environmental damage, algae reproduction may run amok and contribute to mass mortality of other organisms, in the case of algal blooms, for example (Bishop Museum, *Life on Islands*).

Algae & Sea Grass

Based on a 1989 report, approximately 205 known species of macroscopic algae exist for the Northwestern Hawaiian Islands, including Midway and Kure Atolls. Of this list, approximately 48 species are green algae (*Chlorophyta*), 33 species are brown algae (*Phaeophyta*), and 124 species are red algae (*Rhodophyta*). These numbers should increase dramatically with publications currently in preparation and the completion of the taxonomic identification of the 2,055 Northwestern Hawaiian Island algae specimens held by the Bishop Museum in Honolulu (United States Fish and Wildlife Services, *About the Northwestern Hawaiian Islands*).

Bishop Museum. (2002). *Life on Islands*. Join a Research Expedition to the Northwestern Hawaiian Islands. Retrieved May 22, 2002, from http://bishopmuseum.org/research/nwhi/algae.shtml

United States Fish & Wildlife Services. (2002). *About the Northwest Hawaiian Islands*. Honolulu, HI: Author.

MARINE INVERTEBRATES

(Photos by Keoki Stender)

Marine invertebrates include a number of very different types of animals: crabs, shrimp, lobsters, clams, sea urchins, starfish, snails, worms, clams, and many others. These animals make up many of the species that make the coral reefs of the Northwestern Hawaiian Islands such a diverse and interesting ecosystem.

Articles: October 11, 2000 - **WHAT ARE SPONGES?**
By Ralph De Felice

Sponges are the most primitive of multicellular animals (metazoa). They have a cellular grade, which means they have no true tissues. Adults are asymmetrical or radially symmetrical. Sponges are exclusively aquatic (water dwelling), most are marine. They are found from deepest oceans to the edge of the seam and from the coldest oceans to the tropics. Sponges play important roles in so many marine habitats but we still know very little about their diversity, biology and ecology as compared with most other animal groups. In many benthic (sea bottom) habitats sponges are often the dominant animals.

Sponges have an amazing range of growth forms, best described as highly irregular and sometimes completely plastic, frequently altered by prevailing external conditions (currents, turbidity, salinity etc.). Sponges come in just about every color imaginable. Adult sponges are sedentary (sessile), attached to the seabed or other substrate for most of their lives, although many have larvae that motile, swimming or crawling away from their parent. Sponges have sexes that are separate, or sequentially hermaphroditic, although most population dispersal and recruitment is asexual (through budding, fragmentation from storm events, etc). Larvae are motile, incubated within the parent or broadcast into the seawater.

Sponges filter sea water to eat, breath and excrete waste products. Sponges often have complex water canal systems running throughout the body, with smaller inhalant (ostia) and larger exhalant pores (oscules). Sponges are able to actively pump up to 10 times their body volume each hour, making them the most efficient vacuum cleaners of the sea. Sponges appear to be very stable, long-lived animals, although growth rates vary enormously between different groups. Some sponges can grow centimeters in weeks, and may have shorter life spans. Others sponges, like the living fossil 'sclerosponges' are VERY slow growing, with the largest known individuals (up to 30cm diameter) thought to be around 5,000 years old (which makes them the oldest living individuals on the planet, if this is true!).

FISH

There are probably more than 240 different species of fish that are found in the Northwestern Hawaiian Islands. This is roughly half the total number of species that are found in the Main Hawaiian Islands. Researchers believe this lower diversity is due to the smaller size of the islands and their surrounding reefs, cooler water temperatures, and a more limited variety of habitats to occupy.

The NWHI are home to an interesting behavior by some of the top predators in the ecosystem. While fledgling albatrosses are learning to fly in the summer months, the NWHI are visited by large numbers of Tiger Sharks. The sharks feed on the birds that can't stay aloft.

Many fish in the NWHI have been tested for ciguatera poisoning and some of the top predator fish are considered to be toxic. Ciguatera poisoning occurs when fish feed on certain types of algae that live in coral reef systems. As smaller fish are eaten by larger ones, the toxins gradually become concentrated in the muscles of the fishes at the top of the food chain.

The reef community is characterized by fewer herbivores, such as surgeonfishes and an increase in carnivores, such as damselfishes, goatfishes, and scorpionfishes. The Northwestern Hawaiian Islands are considered integral to fishes in the Main Hawaiian Islands as sources to replenish commercial and recreational fish and lobster populations.

Bishop Museum. (2002). *Life on Islands*. Join a Research Expedition to the Northwestern Hawaiian Islands. Retrieved May 22, 2002, from http://www.bishopmuseum.org/research/nwhi/fish.shtml

Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. (2002). *The Region: The Coral Reef Ecosystem.* Retrieved May 10, 2002, from http://www.hawaiireef.noaa.gov/region/region.html

Fish Links

Hawai'i Coral Reef Initiative Page of the Fish of Hawaii
http://coralreefnetwork.com/marlife/fishes/fishes.htm

Bishop Museum's Hawai'i Fishes page
http://www.bishopmuseum.org/research/natsci/fish/fishimages.html

Learn more about ciguatera poisoning
http://www.emedicine.com/emerg/topic100.htm

Fishes

Approximately 240 fish species were recorded in the Northwestern Hawaiian Islands during a comprehensive fish survey conducted by the State of Hawaii, Department of Land and Natural Resources in 1984. Compared to the 536 fish species known from the Main Hawaiian Islands, Hawaiian Islands National Wildlife Refuge (HINWR) has a relatively low species diversity. Researchers hypothesize that this is due to cooler water temperatures, the relatively small size of the atolls and the islands, and a more limited variety of habitats.

Nonetheless, HINWR reef fish populations are healthy, and the fish biomass is higher than in the Main Hawaiian Islands, due largely to reduced fishing pressures. All trophic levels are well represented, including jacks and several species of sharks. A unique occurrence, peculiar to the Northwestern Hawaiian Islands, is the increased presence of tiger sharks inside lagoons from June to August, which gather to feed on fledging albatross chicks. Pelagic fish species, found outside the lagoons, include yellowfin, albacore, and skipjack tuna; mahimahi; billfish; various sharks; and many others.

Ciguatera tests conducted in the Northwestern Hawaiian Islands identified *Cheilinus unifasciatus* as the most toxic fish species. The authors hypothesized that ciguatera may play a role in the downward population trend of endangered Hawaiian monk seal, although a shortage of prey may play a more important role.

United States Fish & Wildlife Services. (2002). *About the Northwest Hawaiian Islands.* Honolulu, HI: Author.

Shallow Reef

English Name	Hawaiian Name	Scientific Name
Limpets	‘opihi	
Periwinkle snail	pupu kolea	Littorina sp.
Nerite Snail	kupe’e	Nerita picea
Sea Lettuce	limu palahala	Ulva fasciata
Rock-Boring Urchins	‘ina uli	Echinometra mathaei
Coralline Algae	manamana-ula	Porolithon gardineri
Hermit Crab	unauna	Aniculus maximus
Reticulated Brittlestar	pe’a	Ophiocoma brevipes
Christmas Wrasse	awela	Thalassoma trilobatum
Hawaiian Whitespotted Toby		Canthigaster jactator
Arc-eye Hawkfish	pili-ko’a	Paracirrhites arcatus
Black Tiggerfish	humuhumu’ele’ele	Melichthys niger
Oval Chromis		Chromis ovalis
Saddle Wrasse	hinalea lauwili	Thalassoma duperrey
Blue Coral	ko’a	Montipora flabellata
Antler Coral	ko’a	Pocillopora eyedouxi
Tiger Cowry	leho	Cypraea tigris
Slate Pencil Urchins	punohu	Heterocentrotus mammillatus
Manybar Goatfish	moana	Parupenus multifasiatus
Orange Tube Coral	ko’a	Tubastrea coccinea
Linckia Seastar		Linckia multifora
Triton’s Trumpet	pu	Charonia tritonis
Cleaner Shrimp	opae	Lysmata amboinesis
Spotted Boxfish	moa	Ostracion meleagris
Slipper Lobster	ula papa	Scyllarides haani
Yellowfin Goatfish	weke	Mulloidichthys vanicolensis
Hawaiian Cleaner Wrasse		Labroides phthirophagus
Yellow Margin Moray Eel	puhi paka	Gymnothorax flavimarginatus
Bird Wrasse	hinalea’i’iwi	Gomphosus varius
Yellowtail Coris	hinalea ‘akilolo	Coris gaimard
Ornate Butterflyfish	kikakapu	Chaetodon ornatissimus
Black Sea Cucumber	loli	Holothuria atra
Cauliflower Coral	ko’a	Pocillopora meandrina
Banded Coral Shrimp	‘opae kai	Stenopus hispidus

Mid Reef

Orangeband Surgeonfish	na'ena'e	Acanthurus olivaceus
Reef Triggerfish	humuhumunukunukuapua'a	Rhinecanthus rectangulus
Hawaiian Sergeant	mamo	Abudefduf abdominalis
Hawaiian Dascyllus	alo'ilo'I	Dascyllus albisella
Bluefin Trevally	'omilu	Caranx melampygus
Convict Tang	manini	Acanthurus triostegus
Leatherback	lai	Scomberoides lysan
Pennant Butterflyish		Heniochus diphreuter
Orangespine Unicornfish	umaumalei	Naso lituratus
Octopus	he'e mauli	Octupus cyanea
Trumpetfish	nunu	Aulosomus chinensis
Potter's Angelfish	Anela i'a	Centropyge potteri
Hawaiian Anthias		Psuedanthias thompsoni
Yellow Tang	lau'i pala	Zebrasoma flaescens
Raccoon Butterflyfish	kikakapu	Chaetodon lunula
Hawaiian Squirrelfish	'ala'ihi	Sargocentron xantherythrum
Lobe Coral	ko'a	Porites lobata
Long-spined Urchins	wana	Diadema paucispinum
Goldring Surgeonfish	kole	Ctenchaetus strigosus
Spotted Pufferfish	o'opu hue	Arothron meleagris
Milletseed Butterflyfish	lauwiliwili	Chaetodon miliaris
Moorish Idol	kihikihi	Zanclus cornutus
Longnose Butterflyfish	lau wiliwili nukunuku oi'oi	Forcipiger flavissimus

Open Ocean

Short-winged flying fish	malolo	Parexocoetus brachypterus
Giant Trevellay	ulua aukea	Caranx ignobilis
Dolphinfish	mahimahi	Coryphaena hippurus
Portugese Man-o-war	pa'imalau	Physalia physalis
Mackeral Scad	'opelu	Decapterus macarellus
Yellowfin Tuna	ahi	Thunnus albacares
Tiger Shark	mano	Galeocerdo cuvieri
Spotted Eagle Ray	lupe	Aetobatus narinari
Whitetip Reef Shark	mano lalakea	Triaenodon obesus
White Coral	ko'a	Cirrhipathes anguina
Whitemargin Unicornfish	kala kea	Naso annulatus
Gray Reef Shark	mano	Carcharhinus amblyrhynchos
Fire Dartfish		Nemateleotris magnifica
Wire Coral	ko'a	Cirrhipathes anguina
Hawaiian Hogfish	a'awa	Bodianus bilunulatus
Smalltail Wrasse		Pseudojuloides cerasinus
Hawaiian Stingray	hihimanu	Dasyatis hawaiiensis
Peacock Razorfish	laenihi	Xyrichtys pavo
Amberjack	kahala	Seriola dumerili

From Land to Sea

Lesson at a Glance

Islands are connected to the water around them. Students will demonstrate the connections between the land and sea ecosystems.

Objectives

Students will be able to

- Describe both island and sea ecosystems.
- Identify animals that depend on both ecosystems and explain why.
- Make a diagram explaining the connections between land and sea.

Back Ground Information

The Northwestern Hawaii Islands are critical nesting and birthing grounds for the monk seal, turtles and hundreds of thousands of sea birds. The purpose of this activity is to help students understand the connections between the land and sea and how and why animals are dependent upon both ecosystems. See the student readings on the monk seals, the turtles and the sea birds for more information.

Materials needed

- Student Reading pages on the monk seal, turtle and sea birds
- Poster size paper
- Colored pens/poster making materials

Student Activities

Have students read the student reading pages on the monk seal, turtles and sea birds. Encourage them to do more research on the internet. Students are to collect information about these animals and the ecosystems they live in. Using the poster size paper, have them draw the island ecosystem and the surrounding reef and ocean ecosystem. Include the turtles, sea birds and monk seals. Show how these animals are dependent upon both ecosystems. Include any other land to sea connections. Encourage students to write creative stories about the trials and tribulations of some of these animals.

Think about the main Hawaiian Islands. What are some connections between the land and the sea? These could be from the animal point of view or an economical one.

Marine Turtles

English Name	Hawaiian Name	Scientific Name
Hawaiian Green Turtle	Honu	Chelonia mydas agassizi
Hawksbill Turtle	ʻEa	Eretmochelys imbricata
Leatherback Turtle		
Olive Ridley Turtle		

Marine turtles are air-breathing, cold-blooded reptiles that have become highly adapted for life in the sea. Powerful flipper-like limbs and a streamlined body make it possible for these gentle creatures to swim rapidly through the water. Green sea turtles are one of seven species of sea turtles; all of which are listed either as endangered or threatened. In Hawaii, there are four kinds of sea turtle: the endangered Leatherback, Olive Ridley, the Hawksbill and the threatened Green Sea Turtle.

The Hawksbill is known to nest on the Big Island, and the Green Sea Turtle has nests on all islands. The Hawaiian Green Turtle is the more abundant of the two species of marine turtles native to the Hawaiian chain. Green Sea Turtles are primarily vegetarians that feed on marine plants growing in shallow coastal waters. The turtle's common name comes from the color of the fat found inside its body rather than the color of the shell or skin. Most adult Hawaiian Green Sea Turtles are heavily pigmented on the upper surfaces, with some being almost completely black.

Although it is difficult to get an accurate count on how many green sea turtles are in Hawaii, it is believed to be under 1000 breeding females, substantially lower than in pre-Western contact times. Green Sea turtles are found throughout the Main Hawaiian Islands (MHI) and Northwestern Hawaiian Islands (NWHI). Although they historically have nested on all islands, due to beach development and other factors they tend to migrate between their main feeding grounds in the main chain to their breeding and nesting grounds in the NWHI.

In the months of May –September, female turtles who are at least 25 –60 years of age come ashore on quiet, undisturbed, dark, sandy beaches to nest. Nesting takes place on land where the female comes ashore at night several times during each breeding season to bury a clutch of leathery eggs. After crawling from the ocean, a nesting site is selected and excavation first takes place using the front flippers. They dig a pit a few feet deep, then a narrow, circular egg chamber another foot or so deep. The hind flippers then take over and working alternately, carefully scoop out a chamber to receive the eggs. After laying a clutch of around 100 ping-pong ball size eggs, the turtle covers the nest and returns to the ocean before the daylight makes her too warm. Each female will dig up to six nests each season, and 80-90% of all Hawaiian Green Sea Turtles make their nests at French Frigate Shoals. Its long, prehensile tail that extends beyond the hind flippers identifies the adult male. The female's tail barely reaches beyond the end of the shell.

After two months (60 days) of unattended incubation, the small hatchlings work as a group to dig to the surface, possibly attracted by the glimmer of light off the waves. They wait just below the surface until the sand cools down, usually at night, and scamper quickly into the sea. Each hatchling weighs about an ounce, and fits nicely into the palm of an adult's hand. When sexually mature, they will weigh between 200 and 375 pounds, and can be four feet long.

From the moment they emerge from the nest, hatchlings face a treacherous life journey. Ghost crabs, fish and sharks prey on hatchlings, and they can become entangled in vegetation or marine debris, and never make it to the water. Some hatchlings become confused, possibly by light on the beach, and travel the wrong direction, again never reaching the ocean. If the hatchling makes it to the water, it will feed on fish eggs, sponges and worms until it reaches adulthood, or about 14 inches. Adult turtles carry out periodic migrations, often over long distances, between resident feeding areas and beaches where reproduction takes place. The nesting beach is believed to be the same site where the turtle itself was originally hatched.

Green sea turtles have played an important role in Hawaii's history. They were used by the ancient Polynesians for food, tools and ornamentation. The ali'i held strict a kapu on Green Sea Turtles and the turtle population was very healthy. During the 1800's turtle hunters decimated the population, including the NWHI. Today, Green Sea Turtles are listed as threatened, which means they are protected from poaching, and harassment in U.S. waters. Green Sea Turtles need two basic habitats to survive. They need quiet, undisturbed beaches, which are dark at night for both basking and nesting, and undeveloped near-shore areas for foraging.

The Hawksbill Turtle is the second species of native Hawaiian marine turtle, but its range is confined to waters around the MHI. The Hawksbill is easily distinguished from the Green Sea Turtle by its pointed hawk-like beak. Also, the horny plates of the juvenile's shell clearly overlap one another. This characteristic often disappears in the adult. Hawksbill feed on crabs and other bottom dwelling marine invertebrates. Their specialized beak is used to probe into coral and rock crevices in search of food.

Two of the greatest threats to the survival of the Green Sea Turtle are marine debris and a disease called fibropapilloma. Marine debris, especially plastics are particularly hazardous to sea turtles. Turtles can become entangled in certain kinds of debris, and often mistake other kinds for food and ingest it. Cigarette lighters, ballpoint pens, and numerous other kinds of plastics have been found in the stomachs of turtles. Plastics can clog the digestive tract of marine animals, including turtles, causing the animal to either starve to death, or a fatal ulcer to form. Fibropapilloma is a viral disease, which causes large tumors to grow on turtles, often to a size that obscures their vision or interferes with avoiding predators and feeding. Scientists are struggling to research and find cures or preventative measures to halt the spread of this disease.

Himschoot, R. (1997). [Northwestern Hawaiian Islands National Wildlife Refuge: Environmental Educational Outreach Program]. Unpublished manuscript & raw data.

Monk Seals

English Name	Hawaiian Name	Scientific Name
Hawaiian Monk Seal	Ilio Holo I Kauaua	Monachus schauinslandi

Only two species of these rare marine mammals remain in the world. One inhabits remote areas of the Mediterranean Sea, and the other lives in the Northwestern Hawaiian Islands (NWHI). A third species formally existed in the Caribbean, but was forced into extinction during the early 1950's by an increase human use of the seal's habitat. The Hawaiian monk seal is considered endemic to Hawaii (other monk seals are a different species).

Monk seals travel over a wide range, but are not really migratory. They make several deep dives when foraging, sometimes-exceeding depths of 400 feet. Although residing in warm waters, monk seals nevertheless still possess a thick layer of blubber like the seals found in cold climates. The food of monk seals consists of eels, lobster, small octopus and reef fish which are captures at night. During the daytime, resting takes place on isolated and undisturbed beaches and rock ledges. Monk seals were listed as endangered under the endangered Species Act in 1976.

Monk seals live mainly in the Northwestern Hawaiian Islands (NWHI), but occasionally can be seen around the Main Hawaiian Islands (MHI). The population is now probably less then 1,200 and appears to be declining. Besides a ciguatera-related die-off around Laysan Island I the 1970's, it is believed the main cause of this decline is a lack of food. Entanglement in marine debris also costs many seals' lives each year. A behavior called "mobbing" has challenged survival rates among young seals, and many young seals are lost each year in shark attacks. Biologists are struggling to not only understand this cryptic and endangered seal, but to preserve the population with numbers which makes a wild population viable.

Monk seals begin reproducing usually around 5 to 6 years of age, and then usually will pup every two years. Between March and July, mother Hawaiian Monk Seals haul out on beaches of the NWHI to give birth to a single, fully developed black pup, weighing around 25 –30 pounds. In preparation for this event, the mother becomes extremely obese and may weigh over 600 pounds. Extra fat reserves are necessary to produce milk for the hungry pup and also to sustain the mother's own body. During the nursing period, she does not go out to sea in search of food, but rather stays continually with her offspring.

When the pup is a few days old, the mother takes it into the ocean for the first swim. Only the shallow protected waters close to shore are used. This is prevent the inexperienced pup from being swept away by strong currents and exposed to deep waters inhabited by sharks. Several swimming lessons a day are carried out for the duration of the nursing period.

With a continuous supply of rich milk, the pup grows rapidly, and its coat changes from black to silver gray. By the time five weeks have passed, the pup has increase from a birth

weight for 35 pounds to 140 pounds. During this period, the mother's reserves are depleted and she becomes very thin. Weaning takes place by her sudden and permanent departure from the island. From that day on, the young seal is on its own.

Biologists are concerned because they are finding many adult females who will pup when they're still too thin, so them the mother must wean the pup early in order to avoid her own starvation. However, the pup may not be fat enough to survive long enough to learn to forage. This cycle of starvation has cost may seals their lives, especially in the French Frigate shoals area of the NWHI. The normal life expectancy of a monk seal in the wild is 25 to 35 years.

For those pups that do survive weaning, there exists another immediate danger. Because the population of monk seals has become skewed, with a much higher number of males to females, young pups of both sexes are often "mobbed" by older males. Without their mother's protection, these pups can be overrun by adult males, and often will drown. In response to the mobbing problems in the NWHI, biologists relocated 22 male seals to the MHI in 1994. Although this has alleviated some of the stress on newly weaned seals on the breeding grounds of the NWHI, it has created a strong need for increased education among the public in the MHI as seal-human interfaces increases.

In addition, pups are largely defenseless against the tiger sharks, which live near the pupping beaches. The sharks will prey on the monk seals, turtle hatchlings and adults, and newly fledged seabirds, which land on the water and may struggle to take off again.

A number of seals are lost each year to entanglement in marine debris, especially fishing gear. Even if they are not drowned as a result of this entanglement, seals can either drag gear or become injured in attempts to free themselves. Dragging gear is not only exhausting, but can also impede free movement, making the seal susceptible to shark attacks or unable to feed. Injuries from entanglement can become infected and become fatal for the seal. Because of the high incident of seal entanglement, the Western Pacific Regional Fishery Management (WESPAC) established a Protected Species Zone in 1991, which encompasses the main foraging and breeding grounds of the Hawaiian monk seal.

Balazs, G. H. (1976). *Hawaii's Seabirds, Turtles and Seals*. Honolulu, HI: World Wide Distributors Ltd.

Himschoot, R. (1997). [Northwestern Hawaiian Islands National Wildlife Refuge: Environmental Educational Outreach Program]. Unpublished manuscript & raw data.

Seabirds of the Northwestern Hawaiian Islands

Seabirds have the same basic characteristics of other birds, which enable flight, but also have some additional adaptations to their marine environment, which make them quite different from terrestrial birds. Seabirds spend most of their lives at sea, coming to land only for breeding and nesting. There are around 30 species of seabirds in Hawaii, and many of them can only be found in the Northwestern Hawaiian Islands (NWHI). Biologists are hard at work ensuring the future success of these birds, as well as researching their lives histories in order to better understand them.

Like terrestrial birds, seabirds have hollow bones, feathers, and stream-like bodies, all of which make flight possible. Also like land birds, seabirds can, and many do, migrate many thousands of miles annually. Just as land birds, seabirds have specific bill adaptations to help them catch the food they eat. Finally, just as land birds, seabirds add to the food chain by becoming prey, depositing guano on land and in the ocean, or when they decompose, thereby adding or returning nutrients back to the cycle of life.

Since seabirds spend the majority of their lives at sea, they are adapted to a marine environment. They can eat, sleep and rest at sea, needing land only for a few short months to build a nest and raise their young. Seabirds possess a special gland behind their eyes, which desalinates saltwater, so that they can obtain drinking water from the ocean. They have webbed feet, which allow them to take off and land very skillfully on the water's surface. Many seabirds have their feet placed further back on their bodies, in order to use them to help propel themselves downwards during a dive, or to swim and dig burrows better in some species. Some seabirds also will use their wings to help them swim downwards during a foraging dive. Seabirds have monocular vision, useful in spotting both predators and prey.

Seabirds can live at sea only coming ashore to reproduce. In fact, the sub-adult birds of many species can stay at sea may years before they mature to a breeding age. Seabirds nest in colonies of a few hundred to several thousand and even millions of birds. Each species will usually live within a colony of its own, and each has its own kind of nest. For example, the albatross nest either on open, sandy area or in light vegetation, while many petrels and shearwaters dig out burrows and still other species, such as noddies, some bobbies, and frigatebirds build nests of sticks and twigs and other materials in the branches of low beach bushes. Most of the seabirds of the Hawaiian Islands rear their chicks together, with each parent taking turns either brooding the egg, and chick, or travelling sometimes great distances, out to sea to forage.

Seabirds vary from species to species a great deal. In general, however, it can be said they eat fish, squid, and floating materials such as fish eggs. They live anywhere from 5 to 45 years and can have a wingspan of a few inches up to 11 feet. They weigh from a few ounces up to several pounds and some nest only once a year, while others reproduce twice a year. Some seabirds in Hawaii are plunge divers some dip; some scavenge, and some even obtain a portion of their food requirements through pirating. All are threatened in many ways by human activities, and many of the seabirds found in the

NWHI can no longer be found on the Main Hawaiian Islands (MHI), except in small, remote colonies.

Although the threat of feather hunters (for use in stuffing pillows or adorning hats), or other hunters looking for seals, whales or turtles are no longer a great threat for seabirds, humans still impact them greatly. Food chain contamination, whether natural (ciguatera) or human-caused (DDT or agriculture runoff) effect seabirds, as they are very high up in the food chain. Disturbance of breeding and nesting grounds by humans is not frequent in the NWHI, but remains a problem for seabirds attempting to breed or nest on the MHI. Perhaps, the greatest threat to seabirds, and the most humanly preventable, is the entanglement in marine debris, especially plastics. Of particular threat is fishing gear (the NWHI is now a Protected Species Zone, since 1991, which limits fishing activities in the area), and plastic trash, such as soda rings and small, disposable cigarette lighter. All of these plastics have been found in the boluses of seabirds, and can be fatal through either ingestion, which can block the digestive tract or cause ulcers, or entanglement.

Biologists devote much time in the NWHI to the monitoring and study of the various seabirds found there. On Laysan Island, serious efforts have been made to eliminate introduced grass species, which erode nesting habitat, and out compete native vegetation. On Tern Island, most species of seabirds that nest there are banded and monitored for reproductive success. Banding helps scientist to observe, and identify individual birds, while giving information about site and mate fidelity, as well as age and migration of banded birds. Although the birds are generally left to the course of nature, if a bird has suffered a negative impact at the hands of humans (entanglement, oiling, etc.), refuge staff will make an attempt to assist the bird.

Hawaii Audubon Society. (1971). *Hawaii's Birds* (2nd ed.). Honolulu, HI: Hawaiian Audubon Society.

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Muro, G. C. (1971). *Birds of Hawaii* (6th ed.). Tokyo, Japan: Charles E. Tuttle Co., Inc.

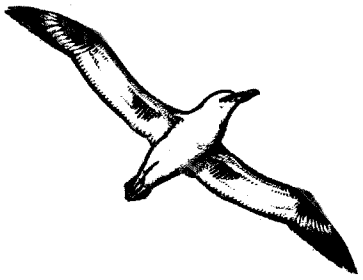
Rauzon, M.J. (2001). *Isles of Refuge: Wildlife and history of the Northwestern Hawaiian Islands.* Honolulu, HI: University of Hawaii Press.

TenBruggencate, J. (1986). *The Honolulu Advertiser's Wildlife of Hawaii* (1st ed.). Honolulu, HI: The Honolulu Advertiser

Names of Sea and Land Birds of the NWHI

English Name	Hawaiian Name	Scientific Name
Albatross	ka'upu	
Laysan Albatross	moli	Diomedea immutabilis
Black-Footed Albatross		Diomedea nigripes
Short-Tailed Albatross		Diomedea albatrus
Red-Tailed Tropicbird	koa'e 'ula	Phaethon rubricauda
White-Tailed Tropicbird	koa'e kea	Phaethon lepturus
Blue-Faced / Masked Booby	'a	Sula dactylatra
Red-Footed Booby	'a	Sula sula
Brown Booby	'a	Sula leucogaster plotus
Great Frigate Bird	'iwa	Fregata minor palmerstoni
Common Moorhen	'alae 'ula	
Brown Noddy	noio koha	Anous stolidus pileatus
Black Noddy	noio	Anous minutus melanogenys
White-Capped Noddy	noio	Anous minutud melanogenys
Blue-Gray Noddy /Necker Island Tern		Procelsterna cerulea saxatilis
Sooty Tern	'ewa'ewa	Sterna fuscata
Gray-Backed Tern	pakalakala	Sterna lunata
White or Fairy Tern	manu-o-ku	Gygis alba
Bulwer's Petrel	'ou	Bulweria bulwerii
Dark-Rumped Petrel	'ua'u	Pterodroma phaeopygia
Band-Rumped Storm-Petrel	'ake'ake	Oceanodroma castro
Tristram Storm Petrel		Oceanodroma tristrami
Bonin Petrel		Pterdroma hypoleuca
Hawaiian Storm Petrel	oeoe	Oceanodroma castro cryptoleucura
Newell's Shearwater	'a'o	Puffinus puffinus newelli
Christmas Island Shearwater		Puffinus nativitatus
Wedge-Tailed Shearwater	'ua'u kani	Puffinus pacificus chlororhynchus
Laysan Duck		Anas wyvilliana laysanensis
Laysan Finch		Telepiza flavissima
Nihoa Finch		Telespiza ultima
Nihoa Millerbird		Acrocephalus familiaris kingi

Did You Know???



Lesson at a Glance

Students will collect fascinating facts about the Northwestern Hawaiian Islands and find creative ways to share them with the class.

Objectives

Students will be able to

- Creatively share facts about the NWHI with classmates.
- Write a children's book about the NWHI.

Materials Needed

- "Fascinating Facts" worksheet
- Access to the following websites:
  Navigatingchange.org
  Hawaiianatolls.org
  PVS-Hawaii.com
- Paper and pencils
- Poster size paper and colored pens

Student Activities

1. **"Northwestern Hawaiian Islands Fascinating Facts Book"**
   Students are to collect "fascinating" facts about the Northwestern Hawaiian Islands and share these with classmates. Have students work in small groups. Assign each group a topic to focus on. This could be the 10 different Northwestern Hawaiian Islands, groups also representing the monk seals, sea birds, and turtles. Start by giving the students a copy of the "Fascinating Facts". Have them find facts on here that relate to their topic. Also encourage them to check out the websites listed above to find more "facts".

   Students are to take these facts, one per page, and illustrate them. Encourage them to think about the format of a children's book. All the pages can be combined together to create a class book.

   You may also want to have students make posters of their facts and display these around the classroom or school.

Fascinating Facts About the Northwestern Hawaiian Islands

General Facts

- The NWHI contains more than 800,000 acres (1,250 square miles) of submerged shoals, coral reefs, and seamounts (that's twice the land surface area of Oahu).
- NWHI is home to 69% of the coral reefs in the United States. This ecosystem is believed by scientists to be one of the last intact fully functioning pristine marine systems of its size in the world.

MidWay

- A thriving colony of approximately 500,000 Bonin Petrels was almost completely extirpated by the accidental introduction of rats to Midway in 1943. By 1979 they had declined to 5,000 pairs and had very little nesting success. A successful eradication of these rats at Midway, completed in 1998, has resulted in a reversal of the decline and increases in the population of this small petrel.
- Midway Atoll is home to the world's largest Laysan albatross colony and the second largest black-footed albatross colony.

Laysan Island

- Laysan Island was described as a "denuded desert" in the Bishop Museum's Tanager Expedition report in 1929 as the scientists described the landscape after rabbits multiplied unchecked there. After years of extensive work to restore and maintain this native ecosystem, the island now has healthy vegetation again and supports the largest complement of native birds in the NWHI.

Unbelievable Flights!

- Sooty terns NEVER sit on the water and after leaving the nest fly at sea for at least a year before touching land.
- An albatross is an amazing efficient long distance flyer. Using its wings like a glider plane, it can fly 62 mph and has been tracked traveling at least 2,000 miles on a round trip voyage from Tern Island to the coast of California during a two-week period.

Fascinating Facts

- In February 2002 Chandler S. Robbins returned to Midway Atoll and recaptured a Laysan Albatross that he had first banded there as an incubating bird on December 10, 1956. This bird must have been at least 5 years old when he first banded it (it would have hatched on or before February 1951), so would have been at least 51 years old when he recaptured it on its nest on February 5, 2002. Albatrosses live a long time and can raise chicks at advanced ages.
- Only a Honu Knows. . .How to Swim Back to French Frigate Shoals.A green sea turtle tracked by scientists swam from French Frigate Shoals at more than a mile an hour, covering a distance of 702 miles during her 23-day migration to Kane`ohe Bay on O`ahu. When turtles are old enough (around 20 to 25 years old), they return as mature adults to lay eggs in the same place they hatched.An estimated 800 female green sea turtles nested at French Frigate Shoals during 2002. Each female can lay three nests holding an average of 100 eggs per nest. . [800x300=240,000]

- Nine out of every ten turtles in the Main Hawaiian Islands were hatched within the protected French Frigate Shoals atoll.

Monk seal Facts

- Monk seals have existed for 15 million years with virtually no evolutionary changes, earning them the title "living fossils."
- Monk seals are one of only two mammals native to Hawaii . . . the other is the Hawaiian hoary bat.
- Comparatively speaking, the monk seal pup count is also impressive. To sight a pup was once an extremely rare occurrence. With a significant reduction in human disturbance over the last 7 years, monk seals are apparently finding Midway's beaches more hospitable. During the past year, a record 15 monk seal pups were born on the atoll.

Home Sweet Home

- On a hypersaline lake lying in the middle of Laysan Island lives the Laysan duck, the most endangered duck in the United States and the one with the smallest home range of any duck in the world. It is only found on Laysan Island.
- Seventy-two terrestrial arthropods, including a giant cricket and giant earwigs, three plant species, and two landbirds, the Nihoa finch and

the Nihoa millerbird, are found only on the Island of Nihoa and nowhere else in the world.

- Native plant community bragging rights go to Mokumanamana or Necker Island and Gardner Pinnacles, which support an all exclusive native plant regime (invasives are not allowed!) providing habitat for hundreds of thousands of nesting native birds.
- USFWS has been continually monitoring tropical sea bird species at Tern Island at French Frigate Shoals for 23 years. This record (the most consistent data set of its kind in the tropical Pacific) details sea bird reproduction and population fluctuations, which provide valuable information about oceanographic events, climate and ecosystem changes.
- Established in 1909, the Hawaiian Islands National Wildlife Refuge encompasses the islands and reefs stretching 800 miles from Nihoa to Pearl and Hermes Reef. This year we celebrate the Centennial of the National Wildlife Refuge System, which has protected this ecosystem for nearly 100 years.
- Maro Reef has much less than an acre of emergent land, but almost 478,000 acres of submerged lands, making it the largest coral reef in the NWHI.
- Lisianski was named for the Russian ship captain who grounded his vessel there in 1805, the first of many recorded shipwrecks there. Three-fourths of the Bonin petrels in Hawai`i nest here along more than a million sooty terns. Its surrounding undersea world is massive in size covering an area over 100 times the size of the island.
- The above sea land area of Gardner Pinnacles consists of only 5 rocky acres yet biologists have sighted over 19 species of birds of which 12 species nest on its precarious cliffs.
- Black-lipped pearl oysters were once so common at Pearl and Hermes Atoll that an entire button industry was supported by them. Due to overharvesting, the species almost disappeared from Hawaii. The Territory of Hawaii made it illegal to harvest these oysters in 1929, but the species has never recovered.

Human Impacts on the Reef

Lesson at a Glance

Students will look at different impacts to the reef, try to figure out what is causing them and what could be done to remedy the situation.

Objectives

Students will:

- Examine clues from the reef to try to determine where the the impacts are coming from
- Describe different ways that humans impact the reef and what be some solutions

Materials Needed

- Student Reading, "Human Impacts on the Reef"
- "Searching For Clues" chart
- "The Case of Claude the Crab"
- "Coral Reef Benefits, Threats and Solutions" Crossword Puzzle

Student Activities

1. **Search For Clues**
   Have students read, "Human Impacts on the Reef" and answer the questions. Share the videos on human impacts (found in the KidScience programs and/or the Navigating Change Educators Kit). Discuss with students different things that can impact the reef. Have the students work in groups to complete the "Searching for Clues" chart. Encourage them to do some research on the internet for more ideas and solutions.
2. **The Case of Claude the Crab**
   This is a creative writing activity. Give students a copy of the worksheet. Read the story about Claude the Crab. Students are then to pretend they are the detective and write about how they investigated the problem and figured out how to solve the problem.
3. **Coral Reef Benefits, Threats and Solutions Crossword Puzzle**
   Have students work in groups to solve this puzzle. Some of the questions are tough. Encourage some internet research of the topics.

Student Reading: Human Impacts on the Reef

Questions

1. What impacts can coastal communities have on reefs?
2. Explain how marine debris can affect animal life.
3. How do introduced species affect the native animals in the ocean?
4. Explain how fishing vessels that have gone ashore can affect the reef.

As people visit the coral reef for recreation or commercial purposes, they change the reef. Many major cities are located on coasts near coral reefs, or along rivers that empty into the ocean. Many things that people put in the water can have an effect on the reef.

Communities near the ocean must be careful about what goes into the storm drains that carry runoff from streets and parking lots. Pesticides and fertilizers used on farms and lawns can also end up washing into the ocean. Municipal or residential sewage systems that release wastewater too close to shore cause an overabundance of algae to grow. Coastal communities and construction that replaces vegetation with bare soil and concrete also increase the runoff of freshwater and sediment into the water. Reef-building corals have a low tolerance for either of these.

Marine debris is another form of pollution. In the last few decades more and more things we use have been made out of plastic. If these objects wind up in the water they drift around, sometimes for years, until they end up on a shore or snagged on the reef. Some of the items are merely unsightly. Others are dangerous to marine life. Sections of old net can continue to entangle marine life long after they're discarded or lost. Items like cigarette lighters and small plastic toys are mistaken for food items by albatross and then fed to their young chicks who cannot digest or pass them. Many albatross chicks die from this each year.

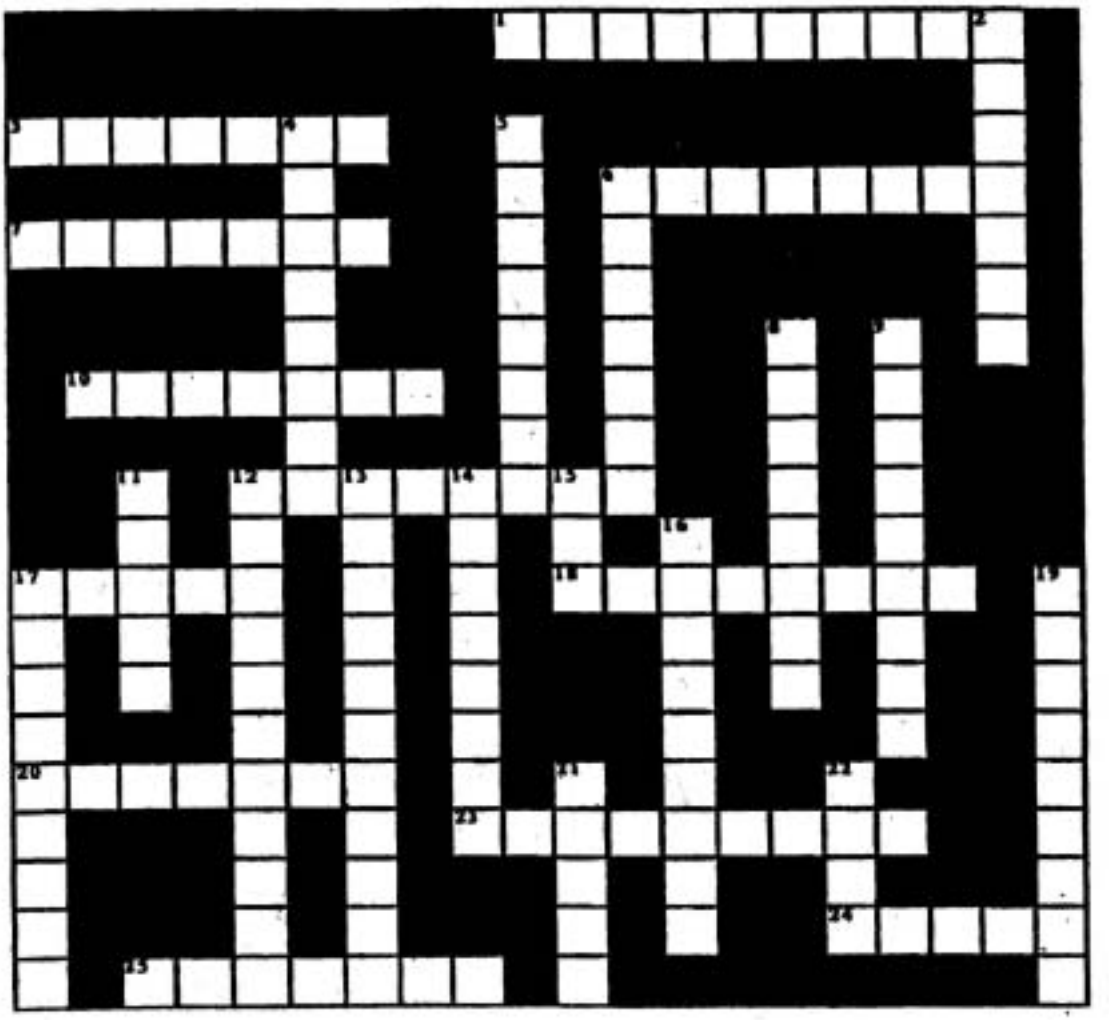
People harvest fish from the reef for food and for the aquarium trade. These are activities that many of us have enjoyed, but must be done with care. Over harvesting of grazers like parrotfish, surgeonfish and sea urchins can result in an overabundance of algae. Anchoring in coral is a source of damage often seen also along our coasts. Divers and snorkelors need to be careful that they don't kick or grab onto fragile corals.

In the past few decades an increasing number of exotic (introduced) marine species have arrived in Hawai'i. In the 1950's several species of snappers and groupers were brought here and released on the reefs. Two of these (Blue-lined Snapper and Argus Grouper) have become very abundant, and are competing with native fish. Non-native aquarium fish and invertebrates have been released by people. These may pose a danger to the reef. If you have aquarium fish that you don't want anymore, you should return them to a pet shop.

Some introduced species arrived here by accident in the ballast water of ocean-going ships. Several species of algae, mollusks, and even fish have arrived this way and are now common, especially in areas like harbors where ships flush their ballast water tanks.

In recent years, at least two large fishing vessels have run aground on the reefs of the Northwestern Hawaiian islands. In addition to the direct damage caused by crashing into the coral, there was the danger that fuel oil from ships would escape into the water. Fortunately this did not happen, but in the past, several small oil slicks of unknown origin have come ashore in the main islands.

CORAL REEF BENEFITS, THREATS & SOLUTIONS CROSSWORD PUZZLE



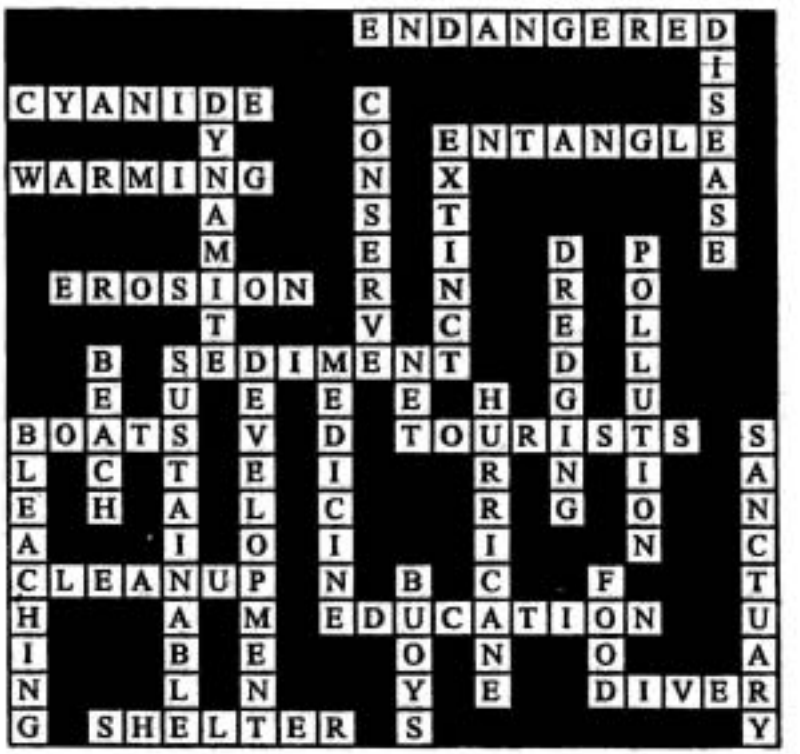
ACROSS

1 In danger of becoming extinct
3 A type of poison used to catch fish
6 To get caught in nets, fishing lines, garbage
7 Global _____, increase in water temperature
10 The washing away of soil
12 Fine particles of solid matter suspended in water or settling to the bottom of it
17 Vehicles that cause damage by anchoring and grounding
18 A source of income that wears tacky shorts and cameras
20 Picking up trash
23 Learning
24 Someone who wears SCUBA gear underwater
25 One of the things the coral reef provides to countless thousands of species of plants and animals

DOWN

2 Illness
4 An explosive used to kill fish
5 To preserve from loss
6 No longer in existence
8 The clearing of channels
9 That which makes something foul or unclean
11 Sandy shore
12 Non-exploitative use of natural resources
13 Building and construction
14 A substance of preparation used in treating disease
15 A nylon or fiber mesh used in fishing
16 A tropical cyclone with winds of 74 miles per hour or greater
17 The expelling of endosymbionts from coral polyps due to stress
19 A marine protected area
21 Moorings used by boats
22 One of the things the coral reef provides to thousands of species of plants and animals

CORAL REEF BENEFITS, THREATS & SOLUTIONS
CROSSWORD PUZZLE
ANSWER KEY



ACROSS
1. ENDANGERED
3. CYANIDE
6. ENTANGLE
7. WARMING
10. EROSION
12. SEDIMENT
17. BOATS
18. TOURISTS
20. CLEANUP
23. EDUCATION
24. DIVER
25. SHELTER

DOWN
2. DISEASE
4. DYNAMITE
5. CONSERVE
6. EXTINCT
8. DREDGING
9. POLLUTION
11. BEACH
12. SUSTAINABLE
13. DEVELOPMENT
14. MEDICINE
15. NET
16. HURRICANE
17. BLEACHING
19. SANCTUARY
21. BUOYS
22. FOOD

"The Case of Claude the Crab"

Your job is to solve the problems of Claude the Crab. Read the story below. Write your own story about what you, the Detective, was able to find out and how the problem got solved.

It was a hot muggy day and I was sitting sleepily at my desk when in rushed the largest crab I had ever seen. He introduced himself quickly as, Claude the Crab, and told me he desperately needed to hire a private detective. Of course, my first question was what crime was it that needed to be investigated. Immediately, he started talking very fast and clicking his claws together in obvious panic. When I could finally get him calmed down so I could understand him, I started to get the picture.....

The crime was attempted murder. This poor crab's home was being destroyed, and he was in grave danger of being killed! He did not have any idea of what was going on or why someone would want to kill him, Claude was sure that he had no personal enemies, and certainly none capable of the magnitude of destruction he was describing.

Then he gave me the first clue. He said that every day, the beaches and the ocean waters became more crowded with dead objects that he did not recognize. He described many shapes, colors and textures. He said that none of the objects were good to eat, and all they did was clutter up the beach. But the most dangerous, by far, were these funny loops of some strange, thin stuff that was almost invisible. Once you had gotten caught in it, it was almost impossible to get free. He was sure that someone was laying traps for him!

The second clue was his story of how some days the very ocean waters turned poisonous with strange colors and disgusting flavors. He said that on those days, he had no choice but to stay out of the water and go hungry until the poisons had dissipated. The water burned his gills too much to go in.

Furthermore, he said that he was not the only one in danger from there criminals. All of his friends in the ocean were in danger. The fish, seals, dolphins and birds were all fighting for their lives against an enemy that they did not understand. I went right to work and after extensive investigation discovered the following...***(You finish the story)***

Who Makes the Decisions?
A Town Meeting

Lesson at a Glance

One solution to protect marine environments is to establish reserves or sanctuaries. This process usually has an impact on different user groups. Public hearings are held to collect information and hear everyone's concerns. Students will participate in a town meeting activity to decide whether to establish a coastal and marine sanctuary.

Objectives

Students be able to:

- Recognize the conflicting interests that determine public policy.
- Make an informed decision on an environmental issue.

Background Information

Environmental policies affect many people. Regulating land uses or human behavior is often controversial. There are often public hearings to find out what people think before regulations are set in place. The opinions often conflict and officials must make choices to best serve the community.

Materials Needed

- Identification Cards for Each Presenter
- Paper and Pencils for City Council Members
- Clock or stopwatch for the timekeeper

Student Activity

1. **Town Meeting**
   Copy the identification cards and number them in the order you would like them to be presented. Choose students to be presenters and hand them a card. Three students are city council members who will listen and make a final decision. One student is a timekeeper who will make sure nobody talks for over two minutes. Students who are not presenters are concerned citizens who can ask questions and choose sides. Place the city council members and the timekeepers at the

head of the room. Introduce the town meeting to the students by reading the paragraph below.

READ TO THE CLASS:
A town meeting has been called and everyone is picking sides. An area may be set aside as a coastal and marine sanctuary. The seabirds, marine animals and coral reef would be protected. There is also a historic heiau on the coast that would be protected. Some people want to protect the area. But this area also has been considered for a hotel. The hotel would provide a lot of jobs. There are also people who use the area for fishing, boating, kayaking and surfing. Would the marine sanctuary kick everyone out? The city council members have called a meeting to hear everyone's opinion and make a decision about the sanctuary.

Have the presenters each speak. Concerned citizens can ask questions between presentations. After the presentations, the city council members will take a short break to decide on the sanctuary. After hearing the decisions, have students discuss the following:

- What do you think of the decision?
- What other information could you have used to make a decision?
- Did you agree with the group you were asked to represent?
- Was any one person right or wrong at this meeting?
- How do officials make decisions when there are so many viewpoints?
- Can officials please everyone?
- What decision would you have made in this situation?

2. **Investigating a Local Issue**
Find a local environmental issue that is being considered by the community. Have students attend public meetings and report back to the class about what is being discussed and different role groups that are involved and their concerns. Invite local community members to come into the class to discuss the issue. Encourage students to write letters, attend sessions and get involved.

(Adapted from Habitat Fun Pack, U.S. Fish and Wildlife Service, 1992)

Issue being considered by the Town Council: "Should an area be set aside as a coastal and marine sanctuary?"
(Give one copy to each student)

"A town meeting has been called and everyone is picking sides. An area may be set aside as a coastal and marine sanctuary. The seabirds, marine animals and coral reef would be protected. There is also a historic heiau on the coast that would be protected. Some people want to protect the area. But this area also has been considered for a hotel. The hotel would provide a lot of jobs. There are also people who use the area for fishing, boating, kayaking and surfing. Would the marine sanctuary kick everyone out? The city council members have called a meeting to hear everyone's opinion and make a decision about the sanctuary."

Bob the Biologist

Remember, Bob, you stand for the birds, fish, and marine animals that live in the coastal and marine environments. These animals cannot speak for themselves. There need to be a few areas on the main Hawaiian islands left undisturbed for these animals. Could this area be one of them?

The seabirds come in from the ocean to use the land as nesting area. Without protection, their nesting areas would be built over.

Monk seals and sea turtles haul out on the shore to rest and to give birth or lay eggs. They need a quiet, protected area.

Whales, dolphins, and coral reef animals live offshore. They all need an undisturbed, protected area.

Samantha the Surfer

Remember, Samantha, you represent all the surfers, kayakers, snorkelers, scuba divers, and swimmers who use this area for fun. These sports do not injure the environment and they bring in tourists who spend money in the community.

Kauai has some of the best surfing in the world and surfing is a traditional Hawaiian sport. A lot of people would be upset if this area was closed.

The coral reef is a great place to snorkel and scuba dive. It also creates a protected area for swimming. There are also people who just like to come and sit at the beach.

Why can't there be a sanctuary that allows for people who don't harm the environment? Does the sanctuary have to kick everyone out?

Dan the Developer

Remember, Dan, you have been thinking about building a hotel on this land for quite a while. If the sanctuary is created, you won't be able to build a hotel.

A hotel would create jobs. People have to build the hotel and work in the hotel.

The hotel would also draw more tourists who would spend more money. All the restaurants and stores in the area would benefit.

A hotel would bring money to a lot of people. How does the wildlife help people?

Fred the Fisherman

Remember, Fred, you have fished in this area all your life. Your parents and grandparents fished here and you want your children to fish here, too.

Fishing doesn't harm the environment. Fishermen only catch what they need to make a living. Pollution and overpopulation are the real problems, not fishing.

Fishermen have a respect for the sea and the animals. They would not harm the sea.

Why can't there be a sanctuary that allows the fishermen to continue fishing?

Belinda the Boater

Remember, Belinda, you represent all the boaters who use this area for tours. If this area is closed, you will have lost a place to boat.

Boat tours bring tourists to the area to spend money. The boat tours also teach the tourists about the coastal and marine environment.

The boaters already follow regulations to protect seals, dolphins, and whales. Boats are not allowed to approach or harass whales or seals. The exhaust and the gas fumes from the boat only cause minor damage to coral reefs.

You'll support a sanctuary as long as you are allowed to bring boat tours into the area.

Pam the Planner

Remember, Pam, you have to represent everybody. Your job is to present the best solution to city council.

The area needs money from tourism. The hotel could bring a lot of money to the area. The sanctuary regulations could put people out of business.

But many people visit the area to see the natural and historical resources - the seabirds, marine animals, coral reef, and heiau. If these are slowly destroyed, a tourist attraction will be gone.
The historical heiau needs to be protected for future generations. Fishermen depend on a healthy, unpolluted, ocean. The sports enthusiasts need places to play.

Is there a compromise that will please as many people as possible and protect the wildlife and the heiau? Should there be a sanctuary? What regulations should there be?

Mr. Birdwatcher

Remember, Mr. Birdwatcher, you represent all the bird watchers in the Bird Watchers' Society. You love your birds and want them to be protected.

There are only a few places left for watching seabirds on the main Hawaiian islands and this area is one of them.

A sanctuary would guarantee the protection of this area. You fully support a sanctuary. There should be places where people can watch wildlife.

Ms. History

Remember, Ms. History, you represent all the Historical Society members. You also stand for all the old places left in the area.
A heiau is on the site where the sanctuary will be. A sanctuary would guarantee protection of the heiau.

So many historical places have been lost or destroyed. It is important to save what is left.

The heiau is also important for archaeology - the study of ancient cultures. The heiau can teach about Hawaiian history.

You support the sanctuary because it will save the heiau.

Bronson the BMX Biker

Remember, Bronson, you represent all the bikers in the area. You have been using the coastal area as a riding site for a long time.

There are only a few public areas to bike and this is one. If it is gone, bikers will have less places to ride. Biking is a fun sport and there need to be areas left to bike on.

Bikers only ride on the sand and dirt. They don't hurt the plants or birds. Bikers shouldn't be kicked out of the area; there should just be some education about where it's okay to bike.

You support a sanctuary as long as bikers are still allowed to ride there.

Three City Council Members

Remember, city council members, you have to make a decision that reflects what the community wants You were elected by the people to represent them - all of them.

You must listen carefully to the presenters and the concerned citizens in the audience.

Should there be a coastal and marine sanctuary or should the land be left open for development? If it is a sanctuary, who should be allowed to use the area - fishermen, boaters, surfers, kayakers, snorkelers, scuba divers, BMX bikers, birdwatchers? If it is a sanctuary, what are the rules? If you decide to not have a sanctuary, what regulations should there be? Can the hotel be built? Where can it be built?

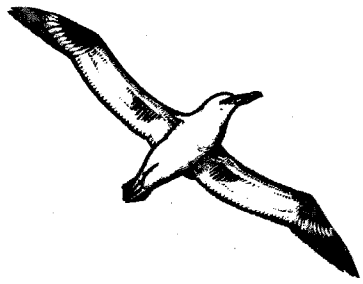
Timekeeper

Remember, timekeeper, everyone is going to be very talkative. Your job is to make sure everyone follows the rules and gets a chance to speak.

Each of the presenters should not go over the time limit of two minutes.

Questions from the concerned citizens in the audience should be short - about 30 seconds each.

The city council members are counting on you to keep order at the town meeting. Good Luck!



Getting Involved

Lesson at a Glance

Students will develop a project or produce a product that helps create awareness about a local environmental issue.

Objectives

Students will

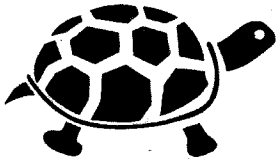
- Identify local environmental issues.
- Develop an awareness project about one of the issues.

Materials Needed

This would vary depending on the project.

Student Activity

1. Students are to identify and gather information about an environmental issue in their community. Students will then develop a project to create awareness of the issue.
   Possible Projects (but not limited to)
   - Plan and carry out a habitat restoration project.
   - Plan and carry out a beach or stream clean up.
   - Design a poster to create awareness of environmental issues.
   - Create a media campaign to create awareness about an environmental issue.
2. The project needs to:
   - Explain/show the issue,
   - Describe what caused this issue, how/why did it start?
   - What impact this issue is having on the community.
   - Describe/show a possible solution to the problem.



TOPIC "Getting Involved"

TASK:

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The project needs to:

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- Describe what caused this issue, how/why did it start?
- What impact this issue is having on the community.
- Describe/show a possible solution to the problem.

	Advanced 4	**Proficient 3**	**D Basic 2**	**In-Progress 1**	**Score**
Collecting Data	Describe the issue. Explain who/what is impacted and how.	Describes the issue or problem.	Identifies issue or problem.	Picks a topic	
Drawing Conclusions	Creates a plan to carry out the solution.	Lists things that need to be considered to be able to carry out the solution.	Identifies a solution.	Begins brainstorming.	
Organizing Information	Creates a rough draft of the project of plan of action.	Organize information on a chart or diagram	Write a description of the issue and the solution	Begin brainstorming ideas.	
Final Product	Presents or carries out the project in an organized or creative manner.	Develops the project or the product, includes the issue and solution.	Sketch/story board of the project.	Describes the product.	
				Total Score	

Sail Away

Lesson in a Glance

Students will design and outfit an ocean going canoe for a voyage to the Northwestern Hawaiian Islands.

Objectives

Students will be able to:

- Build a life size or small model of a canoe.
- Explain what they will take on this journey and why.
- Explain who will make up the crew. What jobs or tasks need to be accomplished.

Background Information

The Polynesians spent several weeks at a time living and sailing on double-hulled canoes. Each hull was made from a hollowed out log. The two logs were connected together and a platform attached to the top of the two hulls. The hulls became storage and the platform the living space. Early Polynesians settlers migrated in these canoes. Everything they owned and would need to start their new life had to go on this canoe. If this was your canoe, how would you design it and what would you take?

Materials Needed

- Paper and colored pens for designing the canoe
- Chalk and yardsticks or measuring tapes for building the life size model
- Hokule'a model: aluminum foil, four plastic straws, chewing gum/putty/clay, cardboard, tape, construction paper, stapler and staples, hole puncher and needle and thread
- Creative canoe models: assorted materials for building double hulled canoes, milk cartons, tagboard, balsa wood.

Student Activities

1. **Life Size Canoe Model**

   Create a canoe to actual size to help students understand how big (or little) this canoe actually is. The Hokule'a is 17'6" wide and 62'4" long, this includes the hulls and deck. The deck is about 9' by 50'. Have the students draw the Hokulea'a on paper to scale. They need to figure out how big the hulls are if the deck is as stated above. The hulls are used for storage and hammocks hang above them. Let's assume that the hulls are the same size. Once they have this figured out have them draw this to actual size. An easy way to do this is to draw it with chalk on the basketball court or parking lot. Have 12 students get on this canoe and pretend to live on it and sail it. This should give them a good perspective of how much space is available on this canoe.

2. **Preparing for the Voyage**

   Imagine that you lived long ago on a small island in the Pacific. You wanted to migrate to a new island to start a new life. How would you go about doing this? Design and draw an ocean voyaging canoe. Include sleeping quarters, a food preparation area, storage etc. Include a scale to show the size. List everything you would take and why. Where would you put it on the canoe? Include all of these items on your drawing of your canoe. Write a short story describing what you think a journey on this canoe might be like.

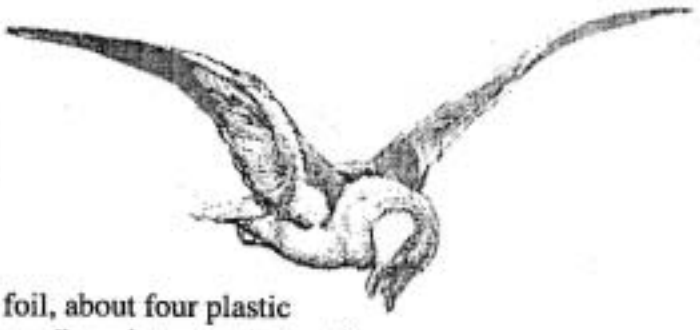
   Make a list of the 12 crew members you think should be on the canoe. What jobs need to be done? What would be important things to think about as you choose your crew?

   After students have complete the project share with them the attached pages on "Daily Living Aboard the Hokule'a" and "Roles and Duties of Hokule'a Crew Members".

3. **Creating Hokule'a Models**

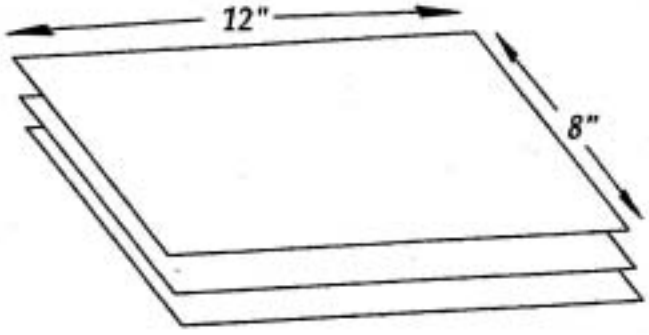
   Challenge students to build a model of the canoe. Attached is a design of a canoe model that could be used.

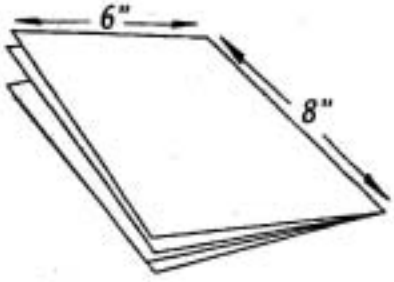
Hokule'a Model



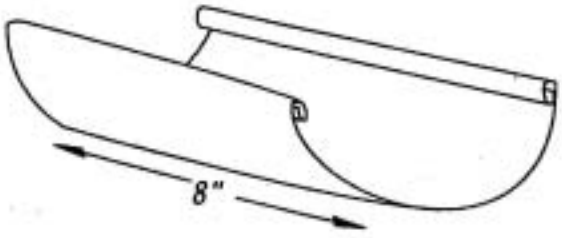
You will need: aluminum foil, about four plastic straws, chewing gum or putty, cardboard, tape, construction paper, stapler and staples, hole puncher, needle and thread

1. Cut three pieces of 8" x 12" aluminum foil. Place together and fold in half to 8" x 6".





2. Fold over the edges twice (this will make the canoe hull more sturdy).

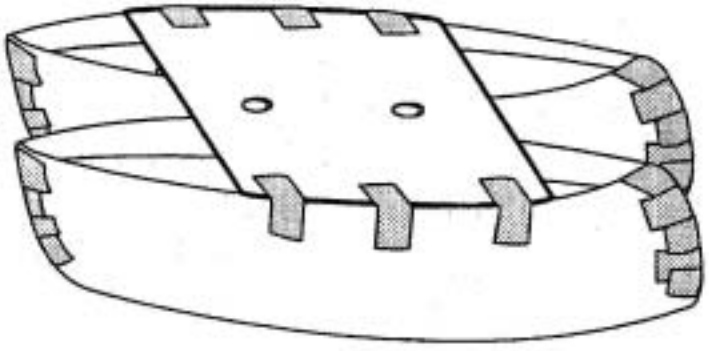


3. Fold in half again. Fold and pinch together ends to form hull shape as below. Then tape along the ends.

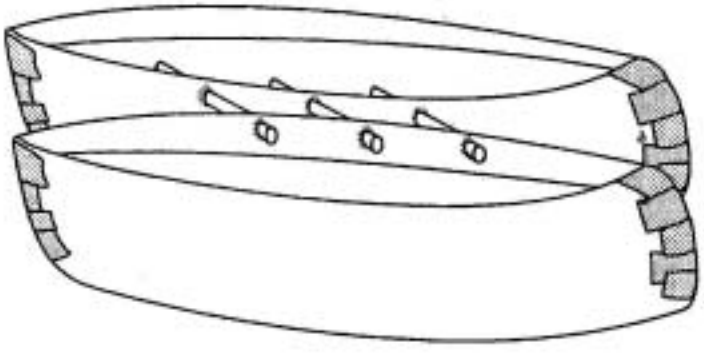
Hokule'a Model (continued)

4. Repeat steps 1 through 3 to make a second hull.

5. Using the hole puncher, make three holes in the side of each hull. Cut your strawsinto three 3" pieces and use them to connect the hulls (see below). Place gum or putty on the inside of the hull to hold sticks in position.

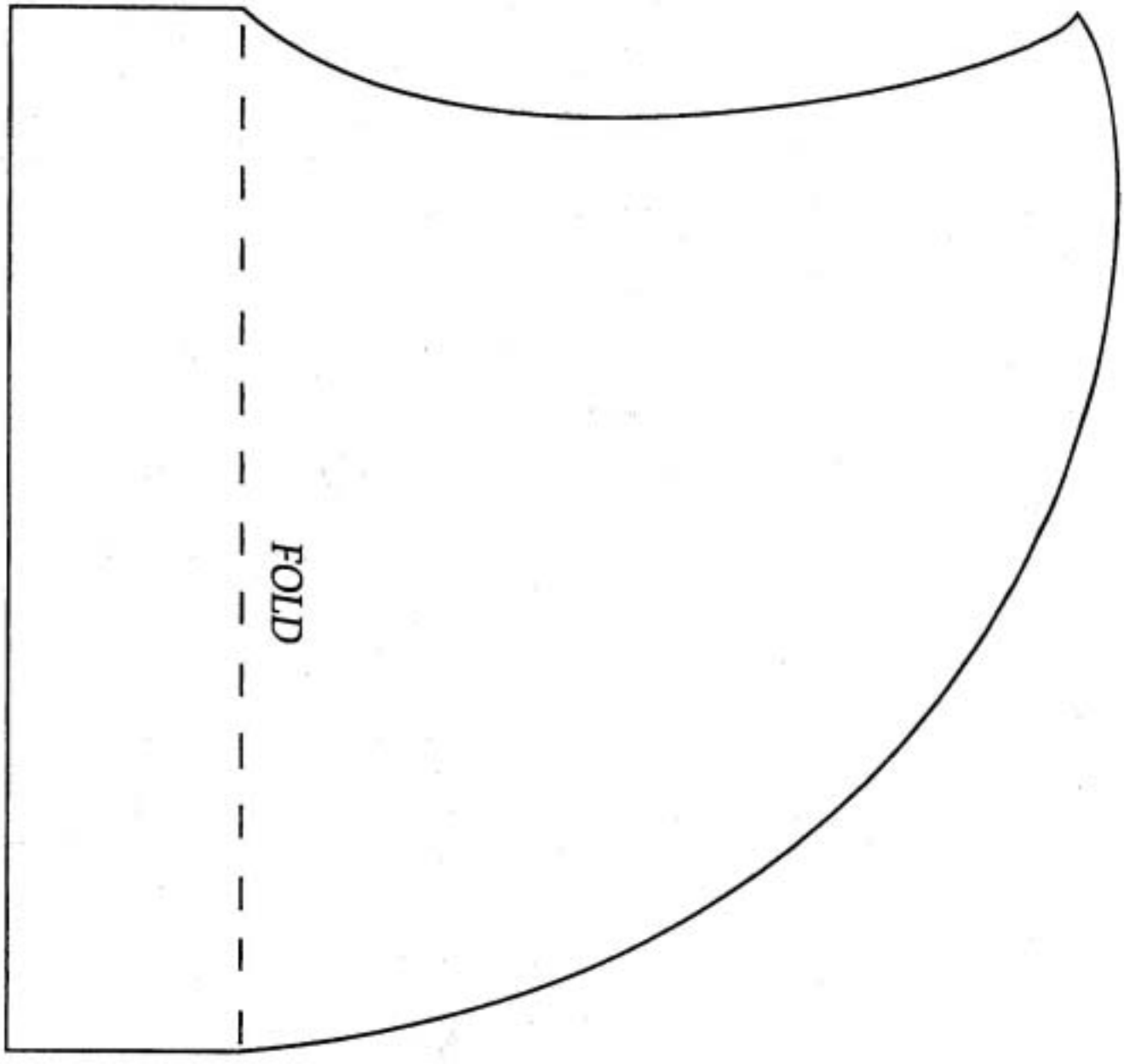


6. Cut a piece of cardboard for the deck, about 5" x 5". Make two holes for the masts. Place the deck on the hulls and tape.



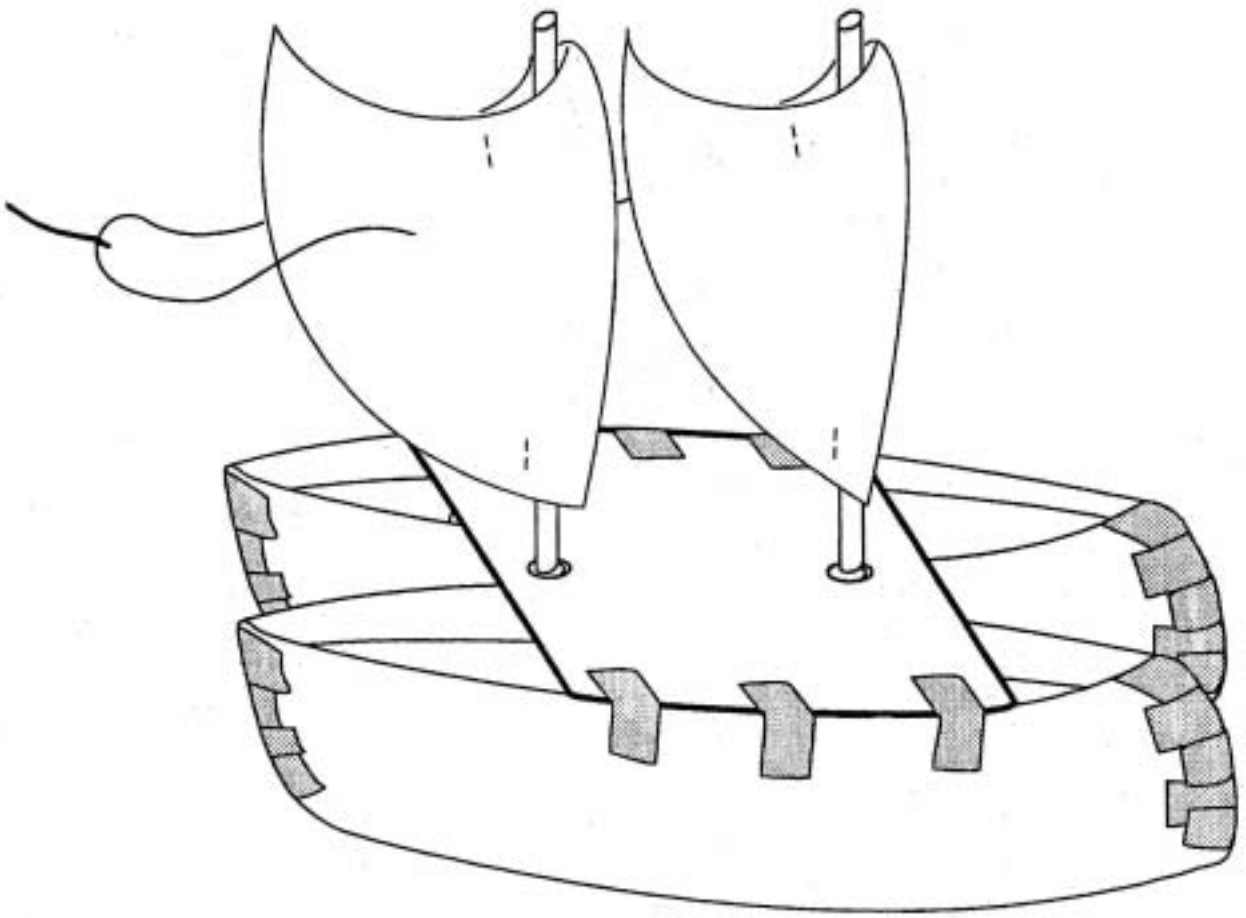
***Hokule'a Model* (continued)**

7. Trace the sail pattern and then cut out the tracings. Place the tracing over a piece of construction paper and cut two sails out of construction paper. Fold the edge of the each sail around a straw and staple (loosely, so that the sail can move back and forth on the mast). Place the masts into the deck.



Hokule'a Model ***(continued)***

8. Use needle and thread to attach a line to each sail. Connect the two lines with aknot so you can control both sails with one hand.



Daily Living Aboard Hokule'a

Eisa Yadao

"Once you go on the canoe, because it's so small, you try to make it like one family."

That is the sailing philosophy of Snake Ah Hee, a 16 year veteran crew member of the Hokule'a. For a dozen plus people to live happily and harmoniously in tight living quarters and over thousands of miles, he and other crew members know the right mental and emotional attitude is key.

Living quarters are tight—roughly 40 square feet of space on Hokule'a's deck. Sleeping quarters are even more cramped and less than comfortable. The sleeping compartments run the length of both sides of the deck and are covered with canvas. Individual spaces measure about 6 feet in length and 3 feet across, usually with two crew members assigned to each bunk. One person sleeps while the other stands watch. Personal belongings are stowed here, with each crew member allowed one 48 quart cooler. Beds consist of a board placed over the coolers, covered by a sleeping pad.

Bathroom facilities, located on either side of ther canoe, take things right down to basics. Going to the bathroom involves strapping a safety harness over your shoulders, hooking the harness to a safety line, and then going overboard to relieve yourself.

Bathing is done either forward or aft on the canoe. Forward, you sit in a net slung between the two canoe hulls. Aft, you bathe in an open compartment, pulling salt water up in a 5 gallon bucket. You use a special sea soap, which makes bathing in salt water actually refreshing.

Because the canoe is so small, privacy is limited at best, but all crew members respect the needs of others. Generally, when someone is bathing or going to the bathroom, the rest of the crew moves away out of courtesy. When women are sailing, certain accommodations are made, such as hanging a curtain over the aft bathing area.

Cooking is done in the center of the canoe. The galley, or kitchen, is a two burner propane gas stove housed in a metal box. By necessity most of the food on board comes out of a box or can, supplemented by whatever fresh fish the crew can catch. Each voyage has a designated fisherman, who puts his trolling lines out off the back of the canoe every morning.

On long trips, food is much more than a source of nutrition and sustenance. Mealtime is one of the few times during the day that the entire crew is together on deck. On long monotonous days, meals are highlight. When the weather is cold and rainy, a hot meal can do wonders for morale.

The canoe carries bottled fresh water for cooking and drinking. On an estimated 30 day voyage the canoe will carry enough water for 40 days at sea. If water supplies become too low, the captain can order that water be rationed. Crew members also store rain water for cooking and bathing.

It takes a lot of work to sail Hokule'a and everyone is assigned a job. Crew members are divided into watches, teams of people who work specific shifts. Generally each person works a four hour shift twice a day, with eight hours off in between. If you

are on the 2 to 6 watch, you'll work from 2 to 6 in the morning and then again from 2 to 6 in the afternoon.

The watch on duty is responsible for maintaining the canoe, working the steering paddles, handling the sails and keeping water out of the compartments. At the start of watch the crew runs through a safety checklist to ensure that Hokule'a is in optimum sailing condition. Each watch has a captain responsible for supervising the others on his or her team.

When crew members are off watch, they rest, read, write in their journals, wash laundry, make music or simply relax and enjoy being out at sea. Time can pass slowly although this is the exception rather than the rule. Being away from home for extended periods of time, the crew does experience ups and downs and homesickness is not uncommon, especially for the crew members. Older crew members have the responsibility to make sure that everyone gets through these low points. Ω

Roles and Duties of Hokule'a Crew Members

Elisa Yadao

Sailing Hokule'a is a rigorous job and it requires the participation of all crew members on board. To ensure that the canoe sails safely and efficiently, each person fills a specific role. Jobs vary from that of the navigator, to those crew members whose primary responsibility is documentation of the voyage for historical purposes. Providing they fill the job requirements, both men and women can hold the various positions described below.

The person who carries the overall responsibility for the canoe and crew is the sailmaster. While he serves primarily in an advisory capacity, it is the sailmaster who has the final say on the canoe's sailing strategy and course and on all other operations of the canoe. He works in consultation with the navigators and captain.

The navigator determines the canoe's course, sets the sailing strategy, and determines the direction in which the crew will sail Hokule'a. He must stay oriented at all times, and this means that generally he is assigned no other duties aboard the canoe. In order to keep track of the canoe's direction, the navigator stays awake 20 hours a day, seated on a platform at the aft of the canoe. Much of the time, the navigator gives direction to the crew through the ship's captain.

The captain's primary responsibility is the safe sailing of Hokule'a and this encompasses everything from ensuring that a capable well-trained crew is on board to the physical maintenance of the canoe. Much preparation is done before the crew and canoe ever leave shore and this is done under the captain's direction. In consultation with the other officers, the captain schedules work parties for preparing the canoe to sail. Relashing canoe parts, mending sails, cleaning and painting Hokule'a's hulls are just some examples of the kinds of work done before sailing.

Another big job is loading the canoe with food, water, and safety gear required on voyages. Again, it is the captain's responsibility to ensure that this is done properly.

At sea, the captain executes all decisions relative to sailing. Once the navigator sets the sailing strategy, it is the captain who directs the crew to hoist, drop or change sails and he determines which steering paddles to use. He is responsible for coordinating activities with the escort vessel and providing a daily work schedule for the watch captains. The captain holds overall responsibility for maintaining the canoe's inventory, and he decides when and if to ration food and water. When approaching land, the captain handles most administrative matters, such as dealing with customs officials and maintaining the canoe's security while it is moored.

The watch captains direct those crew members assigned to their watch or work shifts, carrying out instructions relayed by the captain. The watch captain is responsible for ensuring that his crew is up and on duty in a timely fashion, assigning specific steering positions to his crew and directing rotations through the various positions, going through the safety check list, and maintaining his watch log. He is responsible for maintenance of the canoe during his watch, including cleaning up after meals. Additionally, the watch captain is responsible for monitoring the safety, health and orale of his crew

Other tasks are assigned to crew members and carried out in addition to standing watch. The medical officer, a certified doctor, aboard Hokule'a for each long voyage. His primary responsibility is the health of the crew. It is the medical officer's responsibility to ensure that the canoe is equipped with all medications and medical supplies needed for a long journey. When the canoe is in foreign ports, the medical officer is also responsible for attending to the crew's health and medical needs on shore.

The radio operator handles all radio transmissions between Hokule'a, and the escort vessel and between the canoe and land. He maintains an accurate log of all radio traffic, and is responsible for the upkeep of the radio equipment.

A designated carpenter oversees all repairs done on the canoe. He also maintains the tool inventory. An assigned electrician maintains all electrical systems.

The cook plans the canoe's menus and does most of the cooking. While this may not seem like an important job, the ability of the cook is directly related to the morale of the crew as meals are the highlight of each day. Good nutrition is also an important factor in maintaining the health of the crew.

The quartermaster has direct responsibility for provisioning the canoe—loading food, water and all needed supplies, and for maintaining Hokule'a's inventory. While this is not an on board job, it is critical to the safe and efficient sailing of the canoe. Weight must be evenly distributed for optimum sailing.

Fishing off of the canoe is not a leisure time activity, but an actual designated job, and one crew member is responsible for setting and bringing in fishing lines each day and for landing all catches. Fresh fish provide an important food source at sea.

Documentors keep historical records of the voyage by various means including writing, video and audio taping.

The safety officer is responsible for all safety and emergency systems and equipment. Life jackets, life preservers, flares and fire extinguishers are just some examples of the gear the canoe carries. In addition, all crew members must be trained in man overboard and fire procedures.

Crew responsibilities are exactly the same as the watch captain, with the exception of the administrative duties. Off watch, crew members main obligation is to keep out of the way of those on duty.

Leisure time is spent in a variety of ways including resting, reading, writing, and taking care of personal chores (laundry, cleaning out compartments etc.). In the event of bad weather or an emergency and an all hands on deck call, all of the crew members are expected to work.

All jobs on the canoe, no matter how routine they may seem, are important to the overall safe sailing of Hokule'a. A crew member's most critical responsibility is to realize that his crewmates depend upon him to carry out his assigned duties, and to work well as a part of a team. Ω

Elisa Yadao, Polynesian Voyaging Society Informational Service

Wayfinding
Navigating Using Environmental Clues

Lesson in Glance

Students will participate in activities to learn how environmental clues can be used to navigate.

Objectives

Students will be able to:

- Describe environmental clues used by the Hokule'a to navigate.
- Navigate their own neighborhood using environmental clues.
- Write riddles about navigational clues.

Background Information

Polynesian navigators depended on the sun, moon, stars, waves and birds to help them figure out where they were trying to go. Many hours were spent just observing and evaluating the seas and sky. Listed below are some of the clues the navigators used.

- The sun rises in the east and sets in the west.
- Land birds fly out to sea during the day to catch fish. They return to land to rest in the evening. By following the direction the birds fly in the evening you can aim toward land.
- Winds affect speed and direction. Navigators must know when winds will blow from specific directions to enable them to sail where they wish to go.
- Stars can be used to determine direction. Most stars rise in the east and set in the west.
- Certain clouds form only over land. Certain colors and shapes may indicate where land is. The light green underside of a cloud could indicate that land is close by. High clouds build up over land.
- Ocean swells are usually powered by prevailing winds and can be used to determine direction.
- Changes in the pitch and roll of the canoe were an indication that the canoe was changing direction.

- Turbulence in swells or small waves coming from a particular direction told the navigator that land was near. When swells come in contact with land they are reflected back out to sea.
- Other signs of land would be driftwood, seaweed, animal life, rubbish.
- Deep water is usually blue and a greenish-color of water indicate reefs and shallow water.

Every environment has different clues, which can help define directions and places. Have your students do some very careful observing and see what they can learn about clues in their own environment.

Materials Needed

- Paper and pencils

Student Activities

1. **Searching for Clues**
   Have students brainstorm ideas of clues that the navigators on the canoe might use to help them figure out which direction to go and how to know if they are approaching land. Once they have come up with a list, share the ideas listed above. Encourage students to do some creative writing about the navigating clues, riddles, cartoons, short stories, or poems.

2. **Navigating Your Neighborhood**

- Students are to pick a place in their community that they would like to get to. List where you are starting (Point A) and where you want to end up (Point B).
- Have the students go outside and observe the environment. What is out there that they might use to guide them? What are the clues that might indicate north, south, east and west? List these clues on your paper. Remember that navigators used things besides the stars. Brainstorm other clues you might use.
- Begin your journey at starting "Point A", write out directions, using only environmental clues to get you from "Point A" to "Point B".
- Trade your directions with and classmate and try to follow their environmental clues.