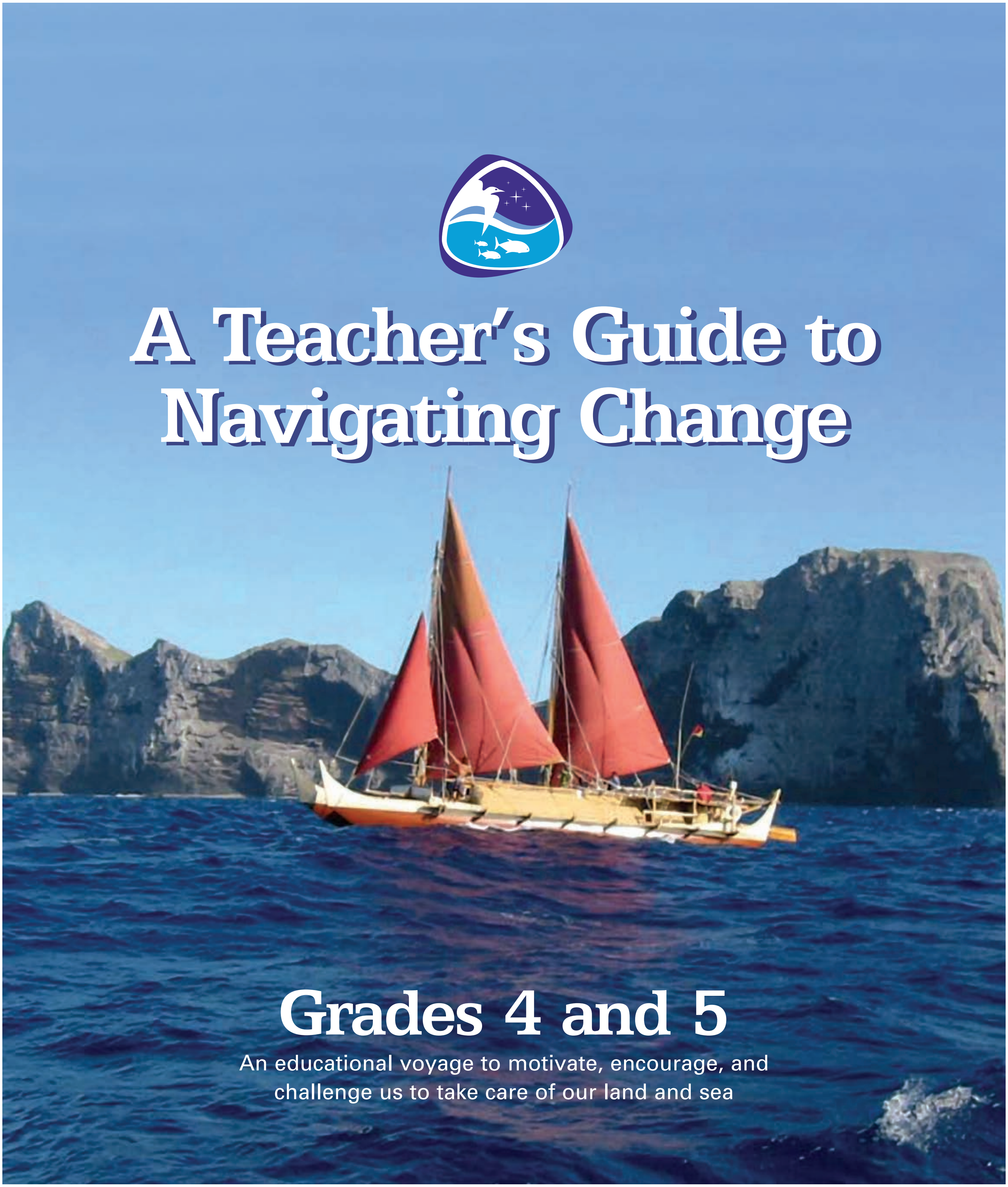

A Teacher's Guide to Navigating Change

Grades 4 and 5

An educational voyage to motivate, encourage, and challenge us to take care of our land and sea

© Photo by Na`alehu Anthony

Navigating Change™

Northwestern Hawaiian Islands

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Navigating Change

"No longer do we seek only the knowledge of how to voyage between islands. We seek lessons to carry home to our children - ways to inspire the present generation to love and preserve our Earth as a sanctuary for those who will inherit it."
—Nainoa Thompson
Navigator, Hōkūle`a

Navigating Change

Navigating Change is a project focused on raising awareness and ultimately motivating people to change their attitudes and behaviors to better care for our islands and our ocean resources. This vision, inspired by the Polynesian Voyaging Society, is shared by partners that include organizations and agencies that share a collective vision for creating a healthier future for Hawai`i and for our planet. We hope to change behaviors by creating an awareness of the ecological problems we face and by demonstrating how decisions we make in our daily lives can help resolve those problems.

Participating partners are:

- Polynesian Voyaging Society (PVS)
- Bishop Museum (BM)
- U.S. Fish & Wildlife Service (FWS)
- National Fish and Wildlife Foundation
- National Oceanic and Atmospheric Administration (NOAA)
- Hawai`i State, Department of Land and Natural Resources (DLNR)
- Hawai`i State, Department of Education (DOE)
- Hawai`i Maritime Center (HMC)
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- Harold K. L. Castle Foundation

Description of the Voyage to the "Kūpuna" Islands

To raise awareness of the environmental decline occurring in the main Hawaiian Islands, the Polynesian Voyaging Society (PVS) has sailed the double-hulled canoe Hōkūle'a throughout the main Hawaiian Islands carrying the Navigating Change message. School children and entire communities were challenged to take responsibility for our natural environment. This statewide sail began in March 2003.

In May 2004, PVS sailed Hōkūle`a along an ancient exploratory route to the Northwestern Hawaiian Islands (NWHI) to further examine the cultural and biological wonders of this unique and rarely seen coral reef ecosystem. These islands have recently been referred to as our "kūpuna" islands since they are geologically older than the main Hawaiian Islands and there is much we can learn from them. The islands provide a window into our past when our coral reefs were healthy and abundant with life. The "ancestral" leg of our journey took us to the islands of Nihoa and Mokumanamana (Necker), where cultural protocols set the stage for the rest of the voyage. The voyage then continued to the remaining Northwestern Hawaiian Islands. These islands revealed a rare sanctuary of natural beauty symbolized by the tiny coral polyp – the building block of life – according to the Hawaiian Creation Chant, Kumulipo.

The remote and relatively unknown NWHI include the northern three quarters of the Hawaiian archipelago, a 2 million acre ecosystem of coral reefs, atolls, small islands, seamounts, banks, and shoals. Over the course of millions of years, erosion, subsidence, and coral reef growth have transformed once-high volcanic islands into the low-lying coral atolls and small basalt islands found here today. Where land and sea rely on each other for life, millions of seabirds nest, thousands of sea turtle eggs hatch, an abundance of sharks and large predatory fish thrive, thousands of marine species flourish, and endangered flora and fauna such as Laysan ducks and Hawaiian monk seals make their home. Countless numbers of native species, more than one quarter of which exist nowhere else on the planet, rely on this relatively undisturbed terrestrial and marine habitat.

While on the voyage to the NWHI, crew members aboard Hōkūle`a communicated by satellite phone with students back home. Updates and information about this voyage are posted on www.pvs-hawaii.org and www.hawaiianatolls.org websites.

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. We want people to take responsibility for the stewardship and sustainability of our islands and our ocean. We are targeting our message to the youth of Hawai`i because the future is in their hands.

Overview of the Navigating Change Teacher's Guide

This teacher's guide includes five units that are designed to help students explore their relationship sto the environment and ways that they can "navigate change" in their own communities. The instructional activities focus on Hawai`i DOE science, social studies, and language arts standards as well as Nā Honua Mauli Ola, guidelines for culturally healthy and responsive learning environments in Hawai`i that were develoed by the Native Hawaiian Education Council in partnership with the Ka Haka `Ula O Ke`elikōlani, College of Hawaiian Language, UH-Hilo. The videotape that accompanies the guide has five segments, one for each unit of study. In addition, the accompanying CD contains a wealth of reference material. A multitude of images and video clips are organized by various subject folders for teachers and students to utilize when creating their own presentations. The CD also contains a beautiful NWHI slide show synced with Hawaiian music, short video segments highlighting management and research activities in the NWHI, and a PowerPoint presentation. References to these resources are included in various units where they support the concepts that students are investigating.

Unit 1: The Voyage

DOE Standards:
Social Studies 7: Geography: World in Spatial Terms
Science 8: Earth and Space Science: Forces That Shape the Earth
Social Studies 6: Cultural Anthropology: Cultural Systems and Practices

Nā Honua Mauli Ola #1-8: Understand and appreciate the importance of Hawaiian cultural traditions, language, history, and values.

This unit sets the stage by introducing students to the NWHI through a mapping activity. Students create a large wall map of the Hawaiian Islands archipelago and present geographical data about the NWHI to one another. The second instructional activity helps students discover the fascinating story of our island volcanoes—from high islands to low-lying atolls. Students then explore what it would be like to take a voyage to a distant island. Along the way, they discover the feats of navigators and the importance of practicing values such as laulima (working together), kuleana (taking responsibility) and mālama (caring).

A wonderful way to supplement this unit is to take students to the Hawai`i Maritime Center where there is a full immersion hands-on exhibit about the NWHI. See http://holoholo.org/maritime/ or call the Center at (808)523-6151.

Unit 2: Land to Sea Connections

DOE Standards:
Science 5: Life and Environmental Sciences Diversity, Genetics, and Evolution
Science 3: Life and Environmental Sciences: Organisms and the Environment

Unit 2 stresses the importance of the interconnection between land and sea as essential components of a healthy environment for many species of the NWHI. Students participate in a role-playing game that emphasizes the importance of land and sea to the survival of Hawaiian monk seals and green sea turtles. Through this activity, students discover the interdependence of organisms for the exchange of oxygen, carbon dioxide, and nutrients; organisms' responses to a constantly changing environment; and the importance of specific environmental conditions for survival.

Unit 3: Change Over Time

DOE Standards:
Science 1: The Scientific Process: Scientific Investigation
Social Studies 7: Geography: World in Spatial Terms
Science 2: The Scientific Process: Nature of Science

Nā Honua Mauli Ola #8-12: Pursue opportunities to observe and listen to expert resources within the community.

This unit lays the foundation for the last two units. Travel through time is simulated through a comparison between the reefs of the NWHI and the main Hawaiian Islands. Students explore the differences between what the reefs of the main Hawaiian Islands might have been and what they are now. The unit includes a PowerPoint presentation that provides a baseline for comparing fish populations and sizes, and reef composition in the NWHI and main Hawaiian Islands. Throughout the unit, students are asked to keep track of all the differences they observe and build comparative models to show their understanding of the concept of change over time.

Unit 4: Human Impact

DOE Standards:
Science 2: The Scientific Process: Nature of Science
Science 1: The Scientific Process: Scientific Investigation

Nā Honua Mauli Ola 315-3&4: Teach others about the concept of mālama through example. Participate in conservation and recycling practices and activities.

This unit challenges students to comprehend both the negative and positive impacts humans have on coral reefs of the main Hawaiian Islands. Students play a game that introduces them to the impact of marine debris. Clues about seabirds and their habitat are revealed as students dissect a bolus and follow principles of scientific inquiry. Through this scientific investigation they become aware of the direct impact of human-made debris on the survival of seabirds. To culminate the unit, student teams create ways to share their new knowledge with other classes in the school.

Unit 5: You Make a Difference

DOE Standards:
Social Studies 1: Historical Understanding: Change, Continuity, and Causality
Social Studies 6: Cultural Anthropology: Cultural Dynamic/Change and Continuity
Social Studies 7: Geography: World in Spatial terms
Math 3: Numbers and Operations: Computation Strategies
Math 10: Patterns, Functions, and Algebra: Symbolic Representation
Science 2: The Scientific Process: Nature of Science
Language Arts 5: Writing: Rhetoric

Nā Honua Mauli Ola #5 - 3&8: Appreciate and respect the diverse views of others. Become actively involved in local activities and organizations that contribute to the quality of life in their community.

The final unit encourages students to apply what they have learned by undertaking projects to mālama the environment. Students reflect on how our use of tools and materials has changed since the days of old Hawai`i, and the ways in which our modern lifestyles have an impact on the environment. Students also conduct a fishing demonstration to explore sustainable fishing practices. In the culminating activity, students are empowered to develop their own environmental actions and be part of the solution by promoting positive environmental changes in their own ahupua`a.

Appendix

The Appendix includes additional readings and resources to supplement the units.

The Voyage

Ulu o ka lā.

The sun grows.

Said of the light of sunrise just as the sun’s rim touches the horizon.
The morning sun is used for navigation to determine the primary direction of east.
— Mary Kawena Pukui, `Ōlelo No`eau #2870

The Voyage

When the sun's rays touch the horizon, the ho`okele (navigator) sets the course for the day's sail. As the sun rises on the voyage of Hōkūle'a to the Northwestern Hawaiian Islands (NWHI), we celebrate the achievements of Hawaiian voyagers, and the opportunities we have to reach out to our island youth with vital messages of caring for the land and sea.

Discovering Our "Kūpuna" Islands

What will we discover about the Northwestern Hawaiian Islands from this voyage? How are these islands, which have recently been referred to as the "kūpuna" islands, different from the main Hawaiian Islands? What knowledge do these "elder" islands hold for us? To begin the voyage, we'll map the "kūpuna" islands and explore geographic data that introduces us to their main features. One of the most striking differences of the NWHI compared to the main islands is that the "kūpuna" islands are much older and smaller. The age and size of the islands as you progress from youngest high island to oldest atoll reveals a fascinating story about the life of our volcanic islands.

Islands to Atolls

Current geological theory holds that a stationary hot spot beneath the Pacific tectonic plate is responsible for the origin of the volcanic Hawaiian Islands and the adjacent Emperor seamount chain, which extend more than 2,000 miles across the north-central Pacific. Islands formed at the hot spot (where Hawai'i Island is now located) are slowly carried to the northwest as the tectonic plate moves. Erosion and island subsidence gradually transformed the high islands to small basalt pinnacles as they moved to the northwest.

As these basaltic islands submerged, fringing coral reefs became atoll reefs. At a point in the archipelago between 27° to 31° N (the "Darwin Point"), coral growth fails to keep up with the continued submergence/erosion of volcanic islands, and the atolls "drown" to form seamounts.

French Frigate Shoals provides an interesting example of a transitional phase in this geological process, since it is an atoll with well developed coral reefs, but it also has a small, basaltic pinnacle (La Pérouse Rock) sticking up in the center of the lagoon.

The Northwestern Hawaiian Islands are a geologically unique area that includes three different land forms: small islands formed from volcanic basalt, with little beach area (Nihoa, Necker, and Gardner Pinnacles); coral islands with fringing reef (Laysan and Lisianski); and atolls formed on top of submerged volcanic remnants (French Frigate Shoals, Maro Reef, and Pearl and Hermes Reef). These islands represent various stages in the volcano erosion and subsidence process, and the subsequent formation of atolls.

Source: United States Fish & Wildlife Services. (2002). About the Northwestern Hawaiian Islands. Honolulu, HI.

On the following page is a list of the NWHI beginning with the islands closest to the main Hawaiian Islands. An important aspect of Hawaiian culture is the awareness that in numerous instances traditional place names either were replaced with foreign ones or the Hawaiian names were misspelled to the degree that their meanings were changed.

The island names of Nihoa and Mokumanamana are the old names that have been passed down through genealogy, stories, and chants. Kānemiloha`i and Mokupāpapa are old Hawaiian names found in chants that have a new association here. These names and other Hawaiian names were assigned to the islands recently by the Hawaiian Lexicon Committee.

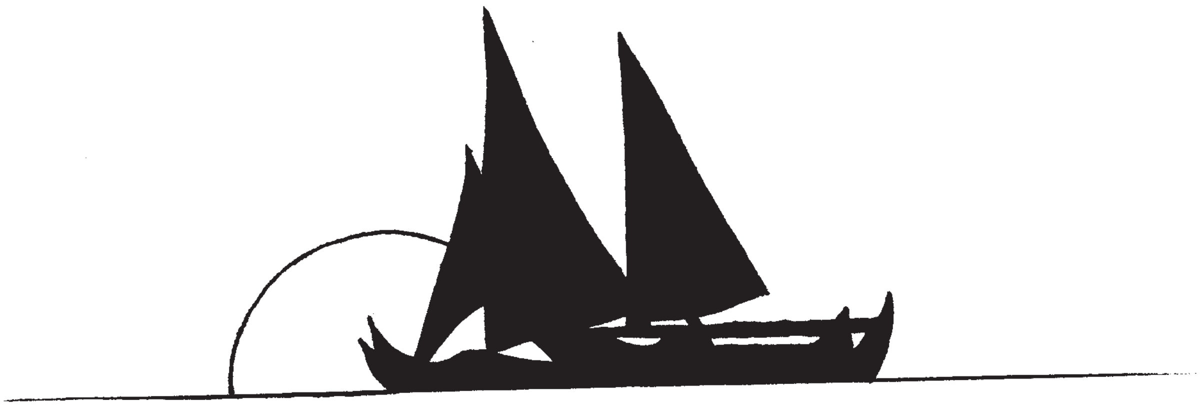
Island Name English	Island Name Hawaiian	Description
Nihoa	Nihoa	A small basaltic islet with many archaeological sites
Necker Island	Mokumanamana	A small basaltic islet with numerous heiau (temple)
French Frigate Shoals	Kānemiloha`i	An atoll of reefs, low sand islets, and the 120-foot-high La Pérouse Pinnacle
Gardner Pinnacle	Pūhāhonu	Means "surfacing of a turtle for air." These two isolated islands and various rock outcroppings seem to appear unexpectedly to voyagers at sea, like a turtle coming up for air, its back and head emerging above the surface. Turtles can often be seen resting on crevices and rock ledges at Pūhāhonu.
Maro Reef	Ko`anako`a	Breakers generally cover this atoll
Laysan Island	Kauō	This flat island surrounded by sand and surf and harboring a pond resembles a bird's egg, cracked open, with the yolk surrounded by egg white. "Kauō" is used to identify the yolk of an egg or the egg white. Kauōis the habitat of thousands of birds.
Lisianski Island	Papa`āpoho	The literal translation describes the physical appearance of Papa`āpoho, a flat island with a depression.
Pearl and Hermes Atoll	Holoikauaua	This atoll is named for the endangered Hawaiian monk seal, which frequents local waters and hauls out on the beaches. Holoikauaua means "dog-like animal that swims in the rough waters."
Midway Atoll	Pihemanu	Along with many of the "kūpuna" islands, Pihemanu is a refuge for birds. Its name means "the loud din of birds."
Kure Atoll	Mokupāpapa	It is the northwesternmost island in the Hawaiian archipelago. It is thought to have been the place where one of Pele's brothers was left as a guard during Pele's voyage to Hawai`i from Kahiki.

Source: Adapted from Kimura, L.L. (1998). Hawaiian Names for the Northwestern Hawaiian Islands. In J.O. Juvik & S.P. Juvik (3rd ed.). Atlas of Hawai'i (p.27). Honolulu, HI: University of Hawaii Press and from the Hawaiian Lexicon Committee.

Hawai`i DOE Content Standards & Nā Honua Mauli Ola	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Social Studies 7: Geography World in Spatial Terms Places and Regions	Where are the "kūpuna" islands—Northwestern Hawaiian Islands (NWHI)—located? How would you compare the major physical characteristics of the different NWHI? Activity: Where are the "kūpuna" islands?	• The Northwestern Hawaiian Islands include a coral reef ecosystem of 10 islands, atolls, submerged banks, and seamounts that stretch 1,200 miles northwest of the main Hawaiian Islands. • The Northwestern Hawaiian Islands include 3 types of islands: 1) Nihoa, Necker, and Gardner Pinnacles are islands with volcanic basalt cliffs. 2) Laysan and Lisianski are coral islands with fringing reefs. 3) French Frigate Shoals, Maro Reef, Pearl and Hermes Reef, Midway, and Kure are atolls.	Assessed: 4.7.2 Collect, organize, and analyze data to interpret and construct geographic representations. Practiced: 4.7.1 Identify the major geographic characteristics and demographics of the pre-contact Hawaiian archipelago, including its relative location to other major land masses.
Science 8: Earth and Space Science Forces That Shape the Earth	How does a Hawaiian volcano change as it ages? Activity: Volcanoes on Stage	• Most Hawaiian volcanoes go through 10 stages beginning with the deep submarine stage and ending with a guyot. • Stream/water, wind and wave action on high islands will eventually erode all volcanic rock. • The high volcanic islands slowly sink and erode away, and corals continue to grow, eventually forming atolls.	4.8.1 Describe how slow processes sometimes shape and reshape the surface of the Earth. 4.8.2 Describe how fast processes (e.g., volcanoes, earthquakes) sometimes shape and reshape the surface of the Earth.
Social Studies 6: Cultural Anthropology Cultural Systems and Practices Nā Honua Mauli Ola #1 Understand and appreciate the importance of Hawaiian cultural traditions, language, history, and values.	What do wayfinding and voyaging reveal about Hawaiian culture and the ability to navigate to distant islands? Activity: Wayfinding	• Pacific navigators have a close relationship to the natural world and are highly skilled at wayfinding—the art of using stars, ocean swells, clouds, winds, and seabirds to navigate to distant islands. • Practicing Hawaiian values such as laulima (working together), kuleana (taking responsibility), and mālama (caring) is essential to successful voyaging.	4.6.1 Explain how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.

Student Journal

Unit 1 – The Voyage



Ulu o ka lā.
The sun grows.

Said of the light of sunrise just as the sun's rim touches the horizon.
The morning sun is used for navigation to determine the primary direction of east.
—Mary Kawena Pukui, `Ōlelo No`eau #2870

Student's Name: ______________________________

School: ______________________________

Date started: ______________________________

Date ended: ______________________________

Student Assessment Overview

You are about to go on an imaginary voyage to discover the Northwestern Hawaiian Islands. Sometimes people call them the "kūpuna" islands because these elder islands have much to teach us. To begin the voyage, we'll map the "kūpuna" islands. We'll explore how they are different from our main islands. We'll learn the fascinating story of how volcanoes change as they age. We'll also find out how Hawaiian navigators read signs in nature to find their way to distant islands. Enjoy the journey!

Unit Essential Questions

- Where are the "kūpuna" islands—Northwestern Hawaiian Islands (NWHI)—located?
- How would you compare the major physical characteristics of the different NWHI?
- How does a Hawaiian volcano change as it ages?
- What do wayfinding and voyaging reveal about Hawaiian culture and the ability to navigate to distant islands?

How you will be graded for this unit:

Individual Journal
It is your responsibility (kuleana) to complete a journal for this unit. Following is a checklist of the pages you will need to include in your journal. Place this page in your journal and make a check next to each item when your complete it. You will be given more details during each lesson.

Journal Pages	✓ Completed
Compare the major differences in the physical characteristics of the "kūpuna" islands.	
Complete individual maps of the Hawaiian Islands archipelago.	
Glue 10 volcanic stage cards in sequence from youngest to oldest and provide labels and captions.	
Illustrate a traditional voyaging canoe and the wayfinding clues that the ho'okele (navigator) uses to find distant islands.	
Write a journal reflection describing what it would be like to be part of the crew in a long voyage. Describe the values and behaviors that would be critical for survival, and how those values and behaviors are also critical for surviving on islands.	
Describe how the canoe, traditional wayfinding, and values are elements of Hawaiian culture and contribute to the preservation of culture.	

Culminating Activity

As you work on your journal, you will be working toward completing the culminating activity for this unit. Your Challenge: Take an imaginary journey from your island to one of the "kūpuna" islands. Identify your role on the canoe (i.e., navigator, captain, cook, etc.). Write in your journal as if you were on the voyage. Include the following:

- A map showing the route the canoe sails, including each island the canoe passes
- Your description of each island the canoe passes and how the island has aged from waves, wind, and water
- How your behavior as a voyager reflects Hawaiian cultural values and practices.

See the sample rubric on the following page to see how you will work toward achieving the standards for this culminating project.

Unit 1 Culminating Activity Rubric

DOE Benchmarks & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Social Studies 7: Geography: World in Spatial Terms Collect, organize, and analyze data to interpret and construct geographic representations. Points ___	Map includes a legend or labels and shows islands in the archipelago accurately located; shows evidence of extra effort to provide details that make the map easier to understand.	Map includes a legend or labels and islands are accurately located.	Map includes some of the islands accurately located; map is adequate, but needs a legend or labels for the islands.	Map does not accurately depict the islands in relationship to one another.
Science 8: Earth and Space Science Describe how slow processes sometimes shape and reshape the surface of the Earth. Points ___	Journal entries use evidence to describe how each island the canoe passes has been affected by waves, wind, and water. Information also includes how the islands have been affected by gradual sinking (subsidence) and the formation of coral reefs.	Journal entries describe how each island the canoe would pass has been affected by waves, wind, and water.	Journal entries provide examples of affects of waves, wind, and water on some islands.	Journal entries recognize that the shaping and reshaping of the islands is due to slow processes but do not describe how islands have been affected by waves, wind, and water.
Social Studies 6: Cultural Anthropology Explain how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture. Nā Honua Mauli Ola #1- 8 Learners understand and appreciate the importance of Hawaiian cultural traditions, language, history, and values. Points ___	Journal entries are creative descriptions of the role of the voyager. Interpretations of how the behavior of the voyager reflects Hawaiian cultural values and practices are insightful.	Journal entries describe the role of the voyager and interpret how the behavior of the voyager reflects Hawaiian cultural values and practices.	Journal entries describe the role of the voyager but do not interpret how the behavior of the voyager reflects Hawaiian cultural values and practices.	Journal entries do not describe the role of the voyager or interpret how the behavior of the voyager reflects Hawaiian cultural values and practices.

Where Are the "Kūpuna" Islands?

Essential Questions: Where are the "kūpuna" islands—Northwestern Hawaiian Islands (NWHI)—located? How would you compare the major physical characteristics of the different NWHI?

Hawai`i DOE Content Standard

Social Studies 7: Geography: World in Spatial Terms

- Use geographic representations to organize, analyze and present information on people, places, and environments and to understand the nature and interaction of geographic regions and societies around the world.

Grade 4 Benchmarks

Assessed:

4.7.2 Collect, organize, and analyze data to interpret and construct geographic representations.

Practiced:

4.7.1 Identify the major geographic characteristics and demographics of the pre-contact Hawaiian archipelago, including its relative location to other major land masses.

Key Concepts

- The NWHI include an ecosystem of coral reefs, atolls, small islands, seamounts, banks, and shoals that stretch 1,200 miles northwest of the main Hawaiian Islands.
- The NWHI include 3 types of islands:
  1) Nihoa, Necker, and Gardner Pinnacles are islands with volcanic basalt cliffs.
  2) Laysan and Lisianski are coral islands with fringing reefs.
  3) French Frigate Shoals, Maro Reef, Midway, and Kure are atolls.

Activity at a Glance

Groups of students collaborate to create a large wall map of the Hawaiian Islands archipelago that includes the NWHI. Groups of students present geographic data about one of the NWHI to their classmates and display the information on the map.

Time

3 - 4 class periods

Assessment

Students:

- Write journal reflections that compare the major differences in the physical characteristics of the "kūpuna" islands as one travels to the northwest from the main islands.
- Complete individual maps of the Hawaiian Islands archipelago.

Rubric

Advanced	Proficient	Partially Proficient	Novice
Collect, organize, and analyze data to interpret and construct geographic representations, with accuracy.	Collect, organize, and analyze data to interpret and construct geographic representations, with no significant errors.	Collect, organize, and analyze data to interpret and construct geographic representations, with a few significant errors.	Collect, organize, and analyze data to interpret and construct geographic representations, with significant errors.

Vocabulary

archipelago – a chain or cluster of islands surrounded by open sea
atoll – a ring-shaped coral reef enclosing a lagoon
basalt – hard and dark volcanic rock formed by the cooling of lava at or near the Earth's surface
fringing reef – coral reef that grows in shallow water and slopes sharply toward the sea floor
"kūpuna" – Hawaiian word for "elder." The NWHI have been recently referred to as the "kūpuna" islands.
latitude – imaginary circles around the Earth, parallel to the equator
longitude – imaginary circles on the surface of the Earth passing through the North and South poles at right angles to the equator

Materials

- student journal and assessment pages (provided in Unit Overview)
- map of the Hawaiian Islands archipelago (provided)
- "kūpuna" islands cards (provided)
- central Pacific map grid (provided)
- island location sheet (provided)
- Navigating Change video segment – "The Voyage" (provided)
- rulers/pencils and colored pens
- large sheets of blue paper or a tarp (to create wall-size map)
- string (for latitude and longitude lines)
- cardstock paper to make island cut-outs
- tape, push pins, or staples

Advance Preparation

Prepare a large wall in the classroom to become a map of the Islands. Cover the wall with large sheets of blue paper or use a blue tarp. If you have projection capability from your computer, project the map of the Hawaiian Islands archipelago onto the wall. (The poster-sized map provided with this teacher's guide is available at http://www.navigatingchange.org/ib_map.asp.). Make cut-outs of the main Hawaiian Islands to place on the wall map during the activity. If there is not enough wall space available, consider developing a large map on the floor. (A floor map could be enhanced with three-dimensional objects, such as figurines of marine animals placed around the islands.)

Duplicate a Central Pacific map grid (one for each student) and the "kūpuna" islands cards (one for each group of two or three students). If desired, make a few copies of the "Fascinating Facts about the NWHI" provided in the Appendix for Unit 1. Make a copy of the student journal and assessment pages provided in the Unit Overview.

Background Information

The Northwestern Hawaiian Islands (NWHI), also known recently as the "kūpuna" islands, are within the northern three quarters of the Hawaiian archipelago. The islands or atolls we see above water are a small portion of the ecosystem known as the NWHI. It's interesting to note that these islands represent only one-tenth of one percent of all emergent land in the archipelago (Rauzon, 2001). Below the islands and atolls is a world of reefs, shoals, and seamounts. This huge region encompasses over 6,800 square miles and stretches 1,200 miles northwest of the main Hawaiian Islands. The 10 most stable and visible islands in the NWHI vary from islands with high basalt cliffs, to low islands, to sandy atolls. Skirting along the fringing reefs of the atolls are many small islands, sometimes called islets, that shift and change with storm surges and wave action. Millions of seabirds, thousands of marine species, endangered land birds, monk seals, and green sea turtles are dependent upon these islands and surrounding reefs.

The Hawaiian Islands are part of a long line of underwater volcanoes. According to the hot spot theory, a hot spot located under the oceanic plate spews out hot molten rock, creating volcanoes. These undersea volcanoes eventually reach 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 hot spot, creating new islands. The older volcanic islands are slowly sinking and eroding away. Eventually these high rock islands become atolls, or rings of coral. The Northwestern Hawaiian Islands include three types of islands: Nihoa, Necker, and Gardner Pinnacles are volcanic basalt; Laysan and Lisianski are coral islands with fringing reefs; and French Frigate Shoals, Maro Reef, Pearl and Hermes Reef, Midway, and Kure are atolls.

Teaching Suggestions

Introducing the Unit:

1. Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.
2. Challenge students to draw a map of the Hawaiian archipelago that includes all of the islands that they know. Check their maps to assess their awareness of our island geography. Ask if anyone included an island beyond Ni`ihau.
3. Introduce the idea of taking a voyage to discover the islands, reefs, and atolls that are found beyond Kaua`i and Ni`ihau. Draw a large "K," "W," and "L" on the board to represent what students "Know," "Want to know," and what they will "Learn" about these islands.
4. Ask students to record what they know of any of the islands that make up the NWHI under the "K" and what they want to know under the "W." Introduce the idea that these are the "kūpuna" islands and discuss how these older islands might look.
5. Show students the Navigating Change video segment: "The Voyage." Discuss what students notice about the differences between the NWHI and the main Hawaiian Islands and add some of the things they have learned under the "L" on the board.
6. Show students the ocean wall you have created to map the Hawaiian Islands archipelago. Project the map of the islands onto the wall and review the names of the islands as you place the main island cut-outs on the map. Have students check the map against the maps they created.

   Main Islands: Hawai`i, Kaho`olawe, Maui, Lāna`i, Moloka`i, O`ahu, Kaua`i, Ni`ihau
   "Kūpuna" islands (NWHI):
   Nihoa
   Mokumanamana (Necker)
   French Frigate Shoals (Kānemiloha`i)
   Gardner Pinnacles (Pūhāhonu)
   Maro Reef (Ko`anako`a)
   Laysan (Kauō)
   Lisianski (Papa`āpoho)
   Pearl and Hermes Atoll (Holoikauaua)
   Midway Atoll (Pihemanu)
   Kure Atoll (Mokupāpapa)
7. Using the projected map as a guide, review latitude and longitude by having students attach strings on the ocean wall map to mark from 155° to 180° West longitude and from 20° to 30° North latitude.

8. Divide the class into groups of two to three students and give each group a "kūpuna" islands card and an island location sheet. Ask students to identify key geographic data and complete the following tasks:
   Group tasks:
   - On their cards, create a to-scale cut-out of the island for the wall map. (Students can trace these from the projected map.)
   - Design a way to display key geographic data and interesting facts about the island on the map.
   - Share information on their cards with the class, including the meaning of the Hawaiian name of the island. (If desired, distribute the Fascinating Facts from the Appendix and encourage students to research the Internet for additional information about their island. An excellent site is: http://www.hawaiianatolls.org/about/index/php.)

9. Turn off the projection of the map on the ocean wall map and ask each group to present their island to the class and place it on the map using the latitude and longitude "address." Use push pins or tape so the islands can be relocated if necessary. As groups share interesting information about their island, have other students take notes.

10. After presentations are completed, project the guide map and see if the groups found the correct island "addresses." Have groups move any islands that are at the wrong address.

11. Have students create Navigating Change journals to use as they voyage through this unit. Distribute copies of the Central Pacific map grid for students to add to their journals. Have students plot the islands on the grid and write journal reflections that compare the major differences in the physical characteristics of the "kūpuna" islands as one travels to the northwest from the main islands. (Note that the geology activity that follows in this unit addresses how the islands form and change as they age.)

12. Have students record what they have learned about the NWHI under the "L" on the board and give them an opportunity to form new questions and place them under the "W."

Extended Activities

Have students use clay, paper mâché, or other materials to collaborate on creating a three-dimensional model of the Hawaiian Islands archipelago. Students could look for rocks that resemble the shape of their islands and use these on the model. Have them include the edges of North America, Asia, Australia, and the South Pole on their model as well.

Challenge each group to learn more about their assigned island. Have them research their island and add information about the flora and fauna and any interesting facts they can find. Include surrounding reefs and any sea animals found primarily on or around their island. Place illustrations or cut-outs onto the large wall map near their island. See Unit 2 Land to Sea for more information about island flora and fauna. Students may want to check out the following websites for more information.

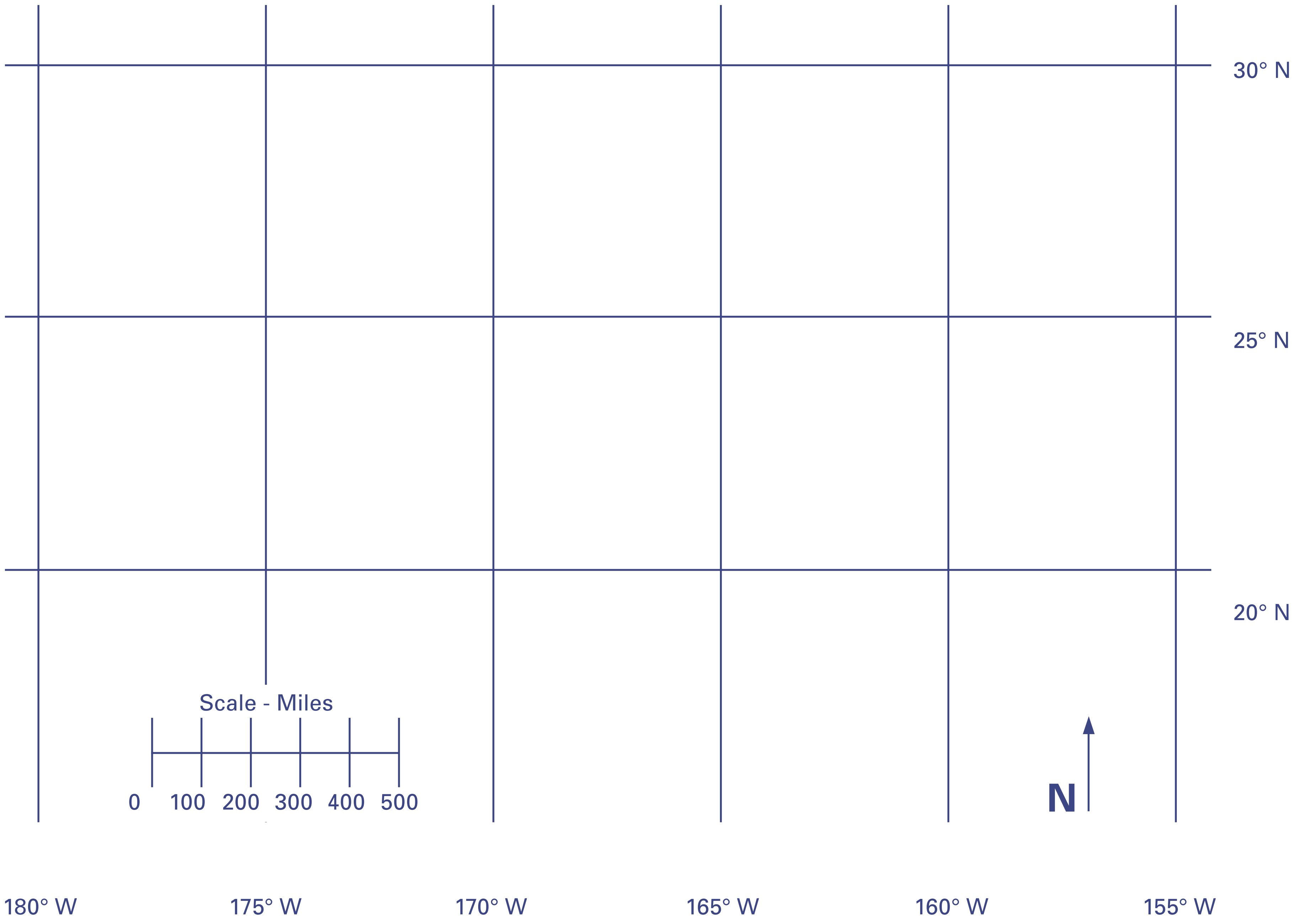
- http://www.navigatingchange.org
- http://www.hawaiianatolls.org
- http://www.pvs-hawaii.com (Polynesian Voyaging Society)

References

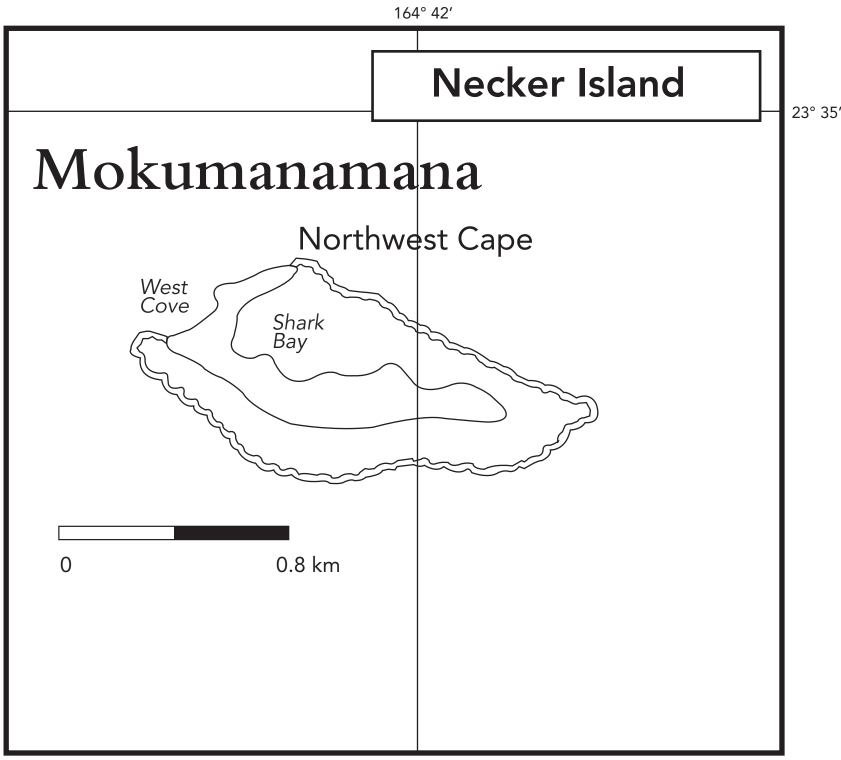
Maragos, J. and D. Gulko (Eds.). (2002) Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim Results Emphasizing the 2000 Surveys. Honolulu, HI. U.S. Fish and Wildlife Service and the Hawai`i Department of Land and Natural Resources.

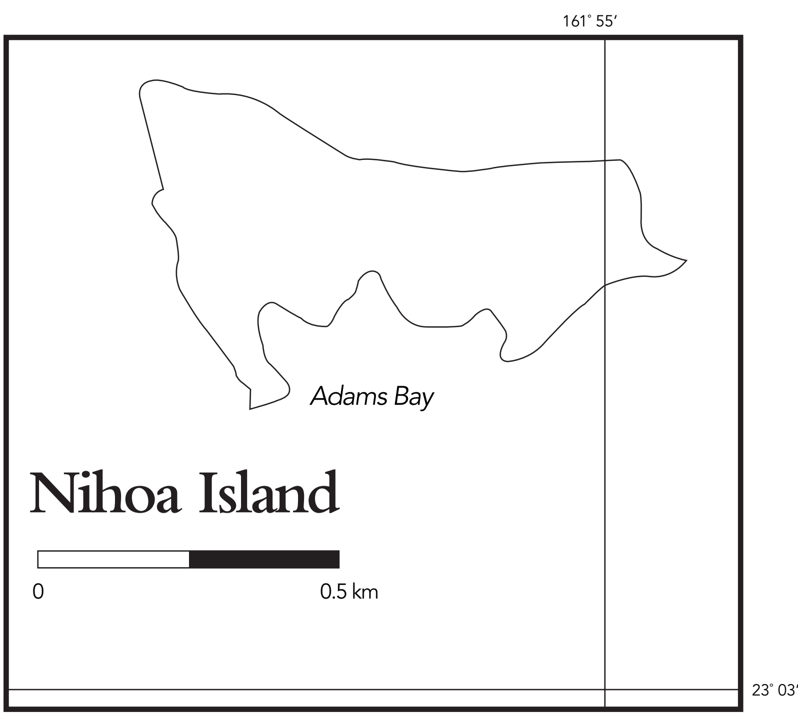
Rauzon, M.J. (2001). Isles of Refuge: Wildlife and History of the Northwestern Hawaiian Islands. Honolulu, HI. University of Hawai'i Press.

Central Pacific Map Grid



Island Location Sheet	Age (million years)	Location (approximate latitude & longitude)
Hawai`i	0 – 0.40	19.5°N, 155.4°W
Maui	0.75 – 1.32	20.8°N, 156.4°W
Kaho`olawe	1.03	20.7°N, 156.5°W
Lāna`i	1.28	21.0°N, 156.9°W
Moloka`i	1.90	21.2°N, 157.1°W
O`ahu	3.70	21.6°N, 158.1°W
Kaua`i	5.10	22.2°N, 159.5°W
Lehua	4.89	22.0°N, 160.1°W
Ni`ihau	4.89	21.9°N, 160.2°W
Kaula	4.89	21.7°N, 160.6°W
Nihoa Island	7.20	23.1°N, 161.8°W
Mokumanamana (Necker Island)	10.30	23.6°N, 164.6°W
French Frigate Shoals (Kānemiloha`i)	12:00	23.7°N, 166.2°W
Gardner Pinnacles (Pūhāhonu)	12.30	25.0°N, 168.0°W
Maro Reef (Ko`anako`a)		25.4°N, 170.4°W
Laysan Island (Kauō)	19.90	25.7°N, 171.7°W
Lisianski Island (Papa`āpoho)		26.1°N, 174.0°W
Pearl & Hermes Atoll (Holoikauaua)	20.60	27.5°N, 175.6°W
Midway Atoll (Pihemanu)	27.70	28.3°N, 177.0°W
Kure Atoll (Mokupāpapa)	27.70	28.4°N, 178.4°W


164° 42′
Necker Island
23° 35′
Mokumanamana
Northwest Cape
West Cove
Shark Bay
0
0.8 km


161° 55′
Adams Bay
Nihoa Island
0
0.5 km
23° 03′

Mokumanamana
Necker Island

The Land

- Necker is shaped like a fishhook.
- It has basalt rocks and steep sea cliffs reaching up to 365 feet above the sea.
- This dry, volcanic island is less than one mile long and 1/5 mile wide.
- There is a healthy native plant community.
- 60,000 birds of 16 species nest here each year.

The Sea

- Large offshore areas are home to manta rays and gray reef sharks.
- There are more than 385,000 acres of coral reef.
- Shark Bay has sea urchins, lobsters and sea cucumbers.
- It's the first island in the NWHI where table corals are found.

The People

- Hawaiians visited here before Nihoa was settled.
- Many shrines are found on the island. They were used for religious and possibly navigational purposes.
- The shrines found here are very similar to those found in the Marquesas Islands to the south.

Nihoa Island

The Land

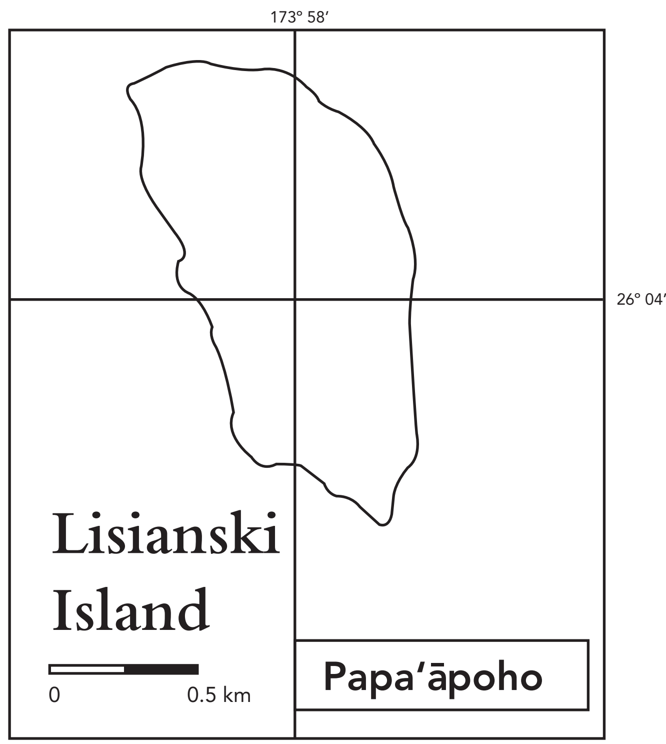
- It's the largest volcanic island in the NWHI chain, with basalt rocks and 900-foot cliffs.
- Native plants and animals include Nihoa finches, Nihoa miller birds, Nihoa palms, land snails, and giant crickets.
- This island has the only remaining intact example of a native Hawaiian coastal scrub community.

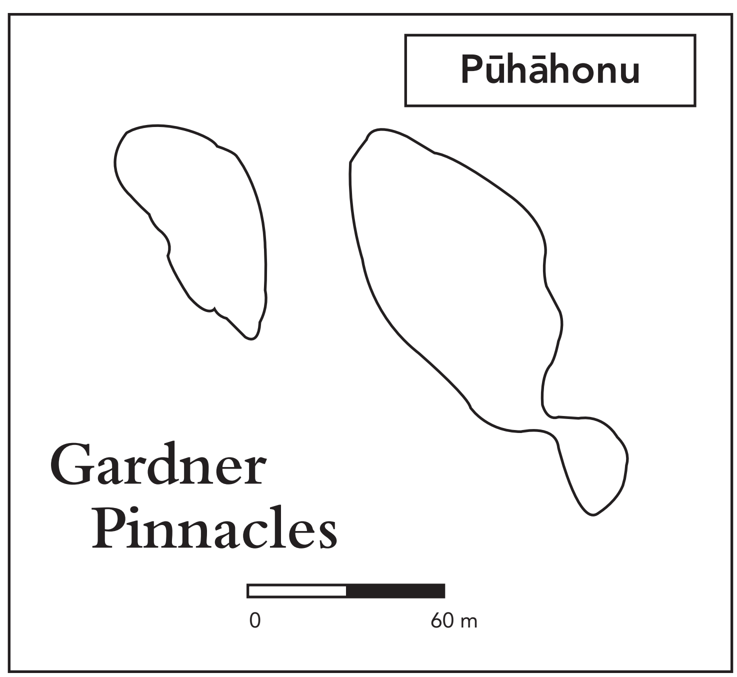
The Sea

- There are not as many varieties of coral found here compared to atolls since there are not as many habitat types, and currents are strong.
- Fish not common in the main Hawaiian Islands but common in the NWHI are first seen here.

The People

- The island was inhabited by as many as 175 Hawaiians sometime between 1000 and 1700 A.D.
- Many archeological features, including house and religious sites and sweet potato terraces, are found here.
- Hawaiians may have regularly visited Nihoa from Ni`ihau and Kaua`i on fishing expeditions.


173° 58′
26° 04′
Lisianski Island
0
0.5 km
Papa'āpoho


Pūhāhonu
Gardner Pinnacles
0
60 m

Papa`āpoho (island with a flat depression)
Lisianski

The Land

- Lisianski is a coral island with fringing reef.
- It is the third largest island in NWHI island chain with 395 land acres.
- A sand dune is the highest point at 40 feet tall.
- It has native beach vegetation.
- It is home to the largest percentage of all Bonin petrels nesting in Hawai`i.

The Sea

- Neva Shoal surrounds the island. It is a huge reef that extends outward 106 miles and is named for the Russian ship Neva that hit the reef in 1805.
- 24 species of stony coral have been found here.
- Large numbers of monk seals find a home here.
- Lobe corals grow in huge undersea mounds 40 feet tall.

The People

- In the early 1900s hunters collected many bird feathers, killing over a million birds. Public concern led to protection of the NWHI.
- Introduced mice and rabbits ate much of the native plants in the early 1900s.
- Plastic pollution comes in on currents.

Pūhāhonu (surfacing of a sea turtle for air)
Gardner Pinnacles

The Land

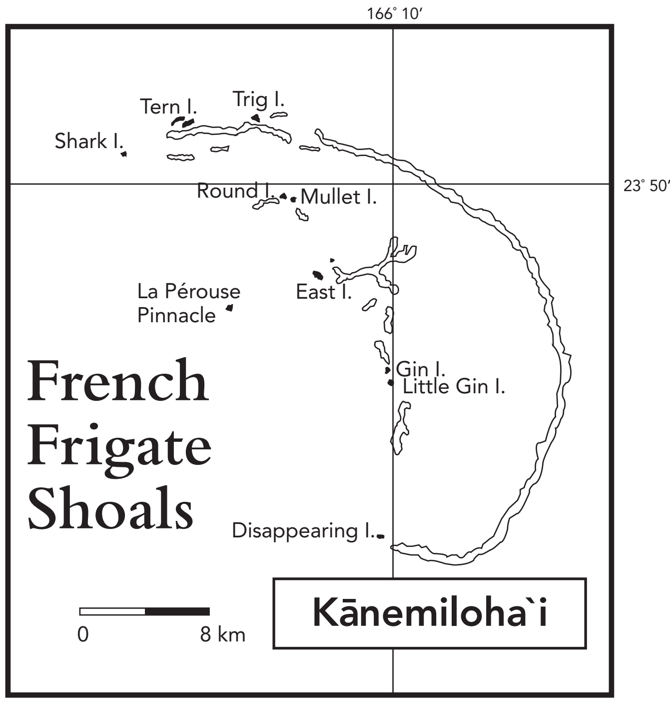
- These two small volcanic peaks are covered with guano from the many birds that roost here.
- The island is only 5 acres with basalt rock sea stacks.
- It's a nesting site for 12 species of tropical seabirds.
- A particular native plant is the island's only established vegetation.

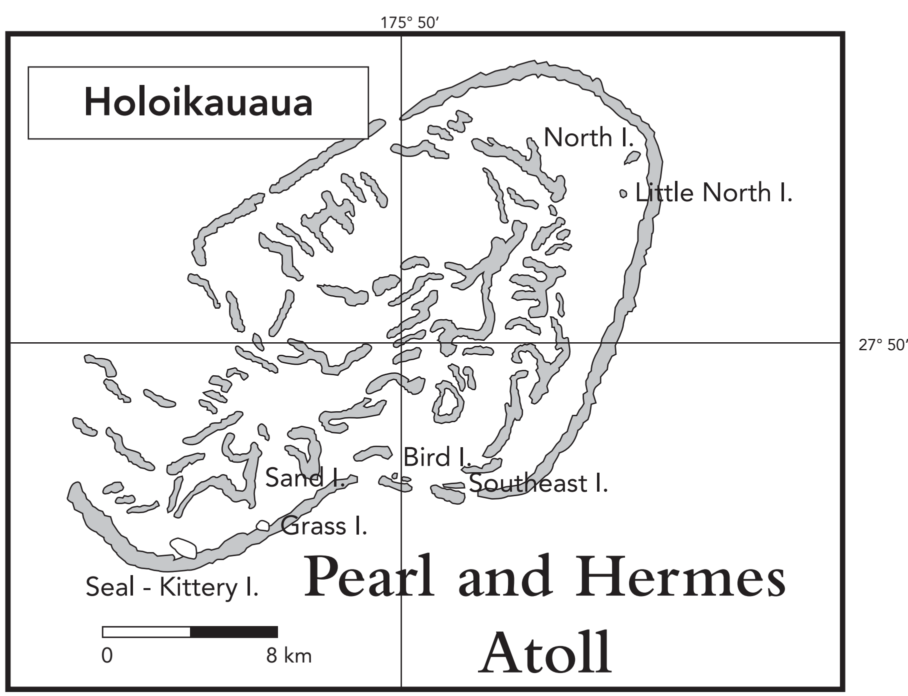
The Sea

- The surrounding reef is 600,000 acres but doesn't have as much coral as Maro Reef.
- It is the home of the giant `opihi—largest of the Hawaiian limpets.
- Many species of fish have been seen here and there are more corals than at Nihoa and Necker.

The People

- The island is very difficult to land on and visitors are rare.


166° 10′
23° 50′
Tern I.
Trig I.
Shark I.
Round I.
Mullet I.
La Pérouse
Pinnacle
East I.
Gin I.
Little Gin I.
French
Frigate
Shoals
Disappearing I.
0
8 km
Kānemiloha`i


175° 50′
27° 50′
Holoikauaua
North I.
Little North I.
Bird I.
Sand I.
Southeast I.
Grass I.
Seal - Kittery I.
Pearl and Hermes
Atoll
0
8 km

Kānemiloha`i
French Frigate Shoals

The Land

- This c-shaped atoll has 12 sandy islets.
- It's the only atoll with basalt structures above water.

The Sea

- This is the largest coral reef area with the highest coral diversity in the NWHI. It is also home to many sponges, worms, snails, lobsters, crabs, shrimp, clams, oysters, sea urchins, and seastars.
- This atoll has the largest population of monk seals in the NWHI.
- More than 90% of all Hawaiian green sea turtles are hatched on these islands.
- More than 150 species of algae, including red, green, and brown types, are found here.
- There is a large shark population.

The People

- Tern Island was enlarged to create a military base during World War II.
- The U.S. Fish and Wildlife Service has a research station here.

Holoikauaua
Pearl and Hermes Atoll

The Land

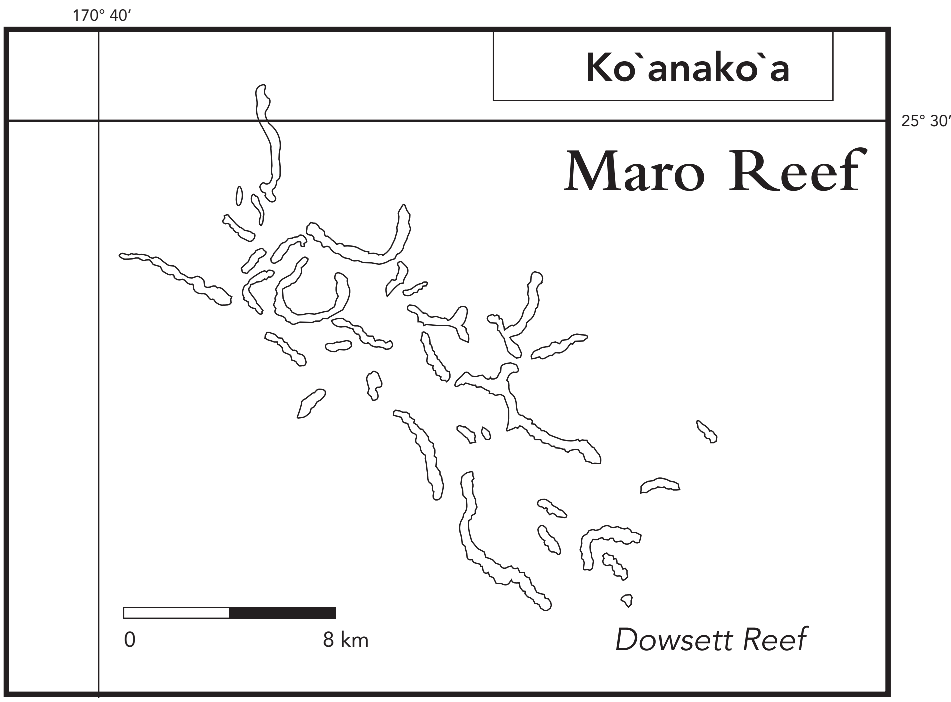
- This large atoll is primarily underwater with 7 small islets. The atoll is fringed with shoals and islets open to the ocean.
- Monk seals, seabirds, and sea turtles rest on the tiny coral islets.

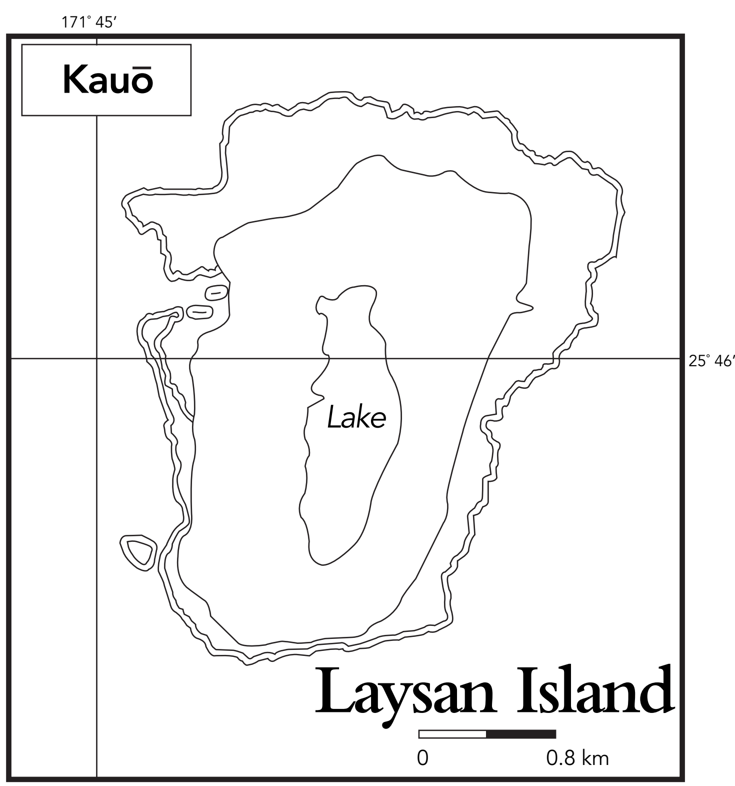
The Sea

- Many species of coral and the highest number of fish in the NWHI are found in the different coral reef habitats.
- Spinner dolphins mate here.
- There are a variety of sponges—possibly 7 new species were collected in 2000.
- The atoll is home to the black-lipped oyster that was once abundant here.

The People

- People collected oysters and used their shells for making buttons. The oysters were nearly gone in less than 10 years.
- Verbasina, an aggressive non-native plant, has spread over the island. It crowds out native species.


170° 40′
Ko`anako`a
25° 30′
Maro Reef
0
8 km
Dowsett Reef


171° 45′
Kauō
25° 46′
Lake
Laysan Island
0
0.8 km

Ko`anako`a
Maro Reef

The Land

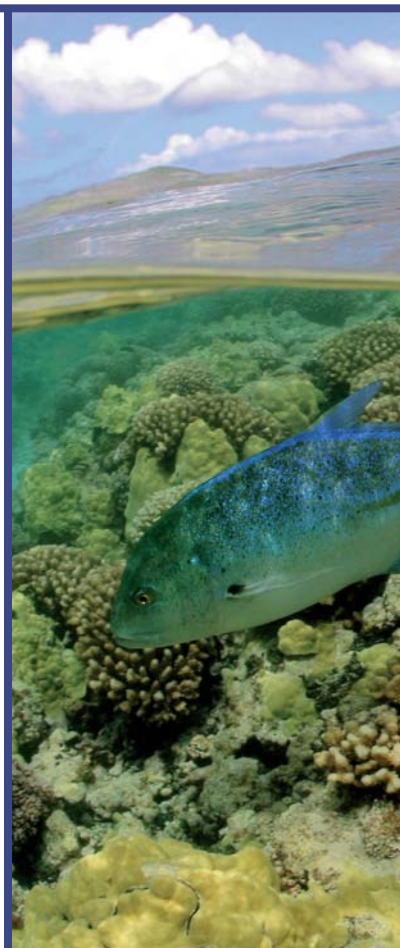
- This submerged atoll has less than one acre of land above water during very low tide.

The Sea

- This is the largest known coral reef in the NWHI (458,540 acres) with the greatest percentage of coral cover.
- The reef is very rich with as many as 37 species of stony corals.
- There are many Galapagos sharks and the water is often murky.

The People

- The reef is very difficult to navigate so it has not been thoroughly explored.
- Captain Joseph Allen of the ship Maro found the reef in 1820.



Kauō(egg representing island's shape and abundant bird life)
Laysan

The Land

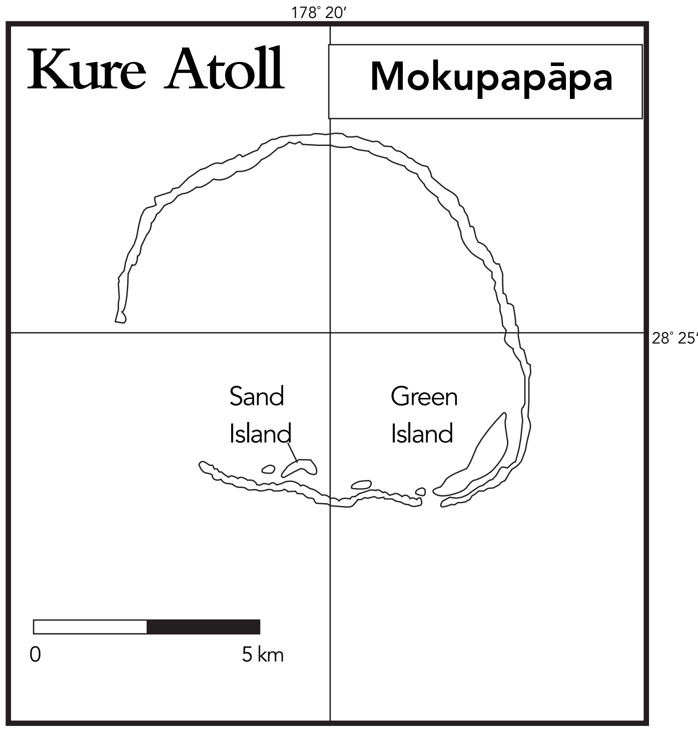
- This is a low-lying sandy island with a very salty lake (15% salinity) in the middle.
- About two million birds nest here, including frigate birds, terns, albatross, and shearwaters.
- The endangered Laysan finch and Laysan duck make their home here.
- The Laysan millerbird, Laysan rail, and Laysan redbird (honey-creeper) became extinct when their habitat was damaged.

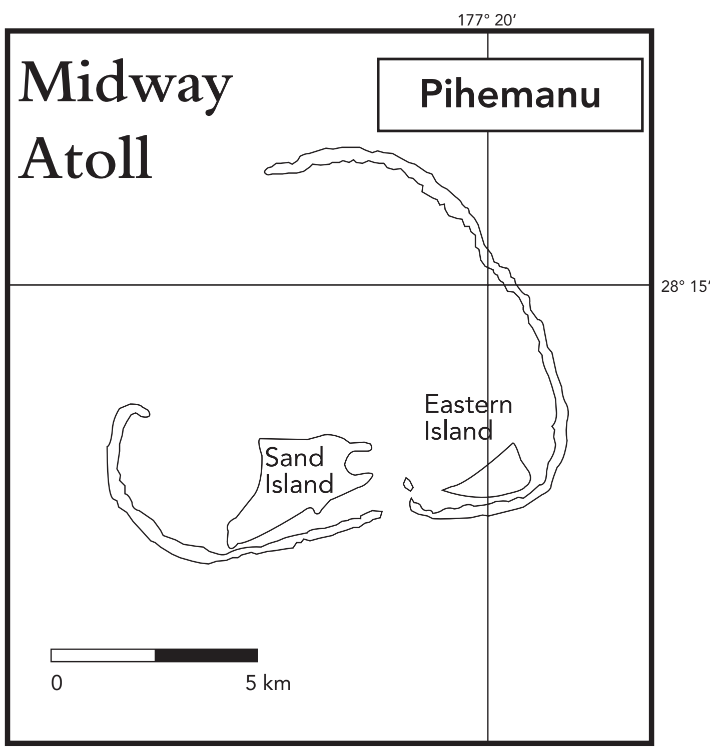
The Sea

- Monk seals, turtles, and sharks swim in waters around the island.
- Most of the shallow water coral reefs are found in a small bay off the southwest side of the island.

The People

- In the early 1900s people began mining for guano (bird excrement used for fertilizer) and harvesting bird feathers and eggs. They also released rabbits and guinea pigs, which destroyed many native plants.
- The U.S. Fish and Wildlife Service has worked hard to restore the native plants to the island. Biologists live in a remote island camp that has solar panels and composting toilets.


178° 20′
Kure Atoll
Mokupapāpa
28° 25′
Sand
Island
Green
Island
0
5 km


177° 20′
Midway
Atoll
Pihemanu
28° 15′
Eastern
Island
Sand
Island
0
5 km

Mokupāpapa
Kure Atoll

The Land

- Kure is a nearly circular, classic atoll enclosing 200 acres of land.
- It is the northernmost coral atoll in the world.
- Rough winter storms occur here.

The Sea

- Large schools of dolphins, jacks, sharks, goat fish, and Hawaiian grouper make the reef their home.
- Many corals, echinoderms, crustaceans, and mollusks are found here.
- Large numbers of macroalgae, green sea turtles, monk seals, and seabirds live here too.

The People

- The island catches lots of marine debris generated by human activities.
- Kure is managed as a wildlife sanctuary by the State of Hawai`i, DLNR.
- Some of Hawai`i's oldest known shipwrecks are found at Kure, including the wreck of a whaling ship from the mid-1800s.

Pihemanu (loud din of birds)
Midway Atoll

The Land

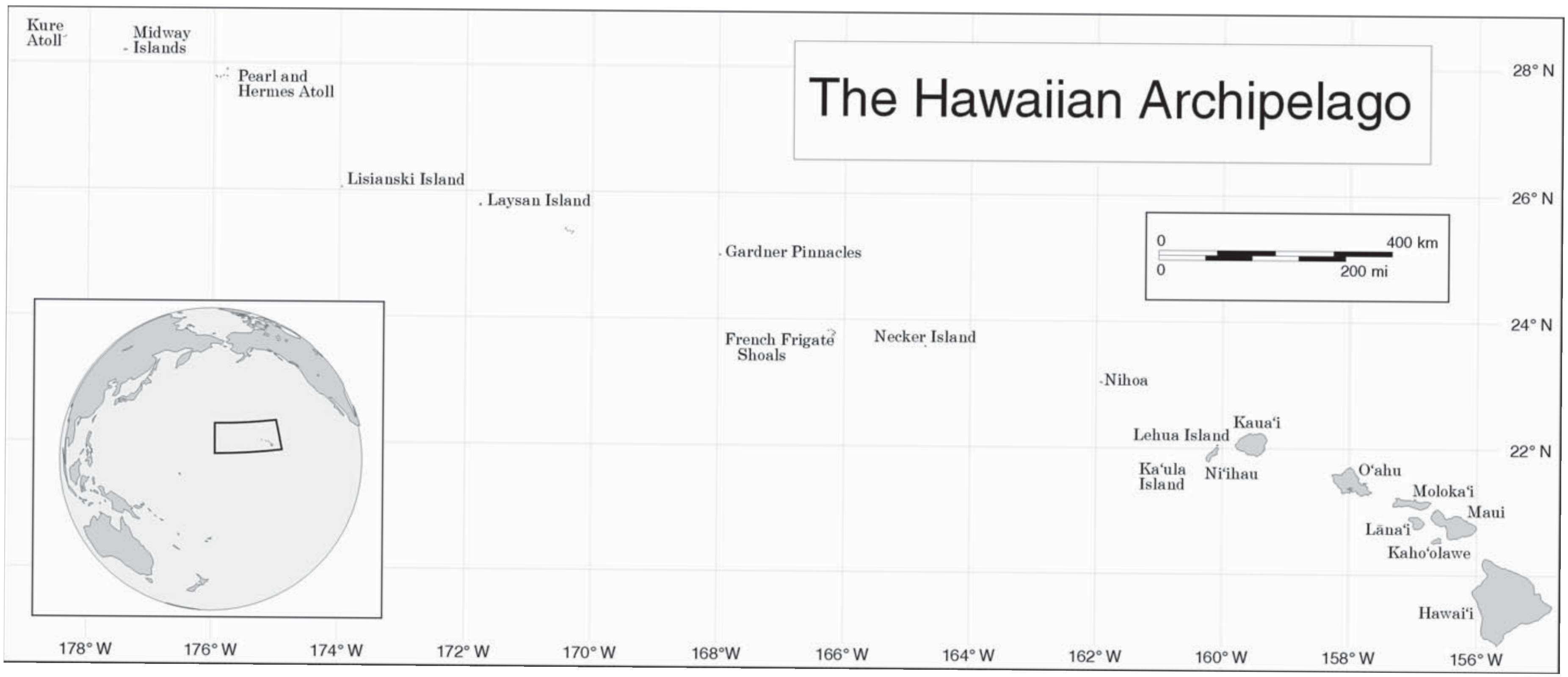
- Midway is a classic shallow water atoll with 3 small islets.
- It has the world's largest colony of Laysan albatross.
- Two million birds use the 3 small islets for habitat.

The Sea

- The coral reefs here are more than 1,300 feet thick.
- The atoll is an important habitat for monk seals.
- Several species of fish common to Midway are also common to Japan's coral reefs.
- Spinner dophins rest in the lagoon during the day and feed outside the atoll at night.

The People

- The first permanent Western settlement in the NWHI was at Midway in 1903.
- People introduced ants, rats, mice, and mosquitos.
- The atoll was a site of a major World War II battle.
- People enlarged Sand Island to create a naval base during the late 1950s.
- Tons of topsoil were imported to grow plants such as ironwood trees.
- Midway became a National Wildlife Refuge in 1988. It has an airport, permanent housing, and research and visitor facilities.


The Hawaiian Archipelago
Kure Atoll
Midway Islands
Pearl and Hermes Atoll
Lisianski Island
Laysan Island
Gardner Pinnacles
French Frigate Shoals
Necker Island
Nihoa
Lehua Island
Kaua'i
Ka'ula Island
Ni'ihau
O'ahu
Moloka'i
Maui
Lāna'i
Kaho'olawe
Hawai'i
0
400 km
0
200 mi
28° N
26° N
24° N
22° N
178° W
176° W
174° W
172° W
170° W
168°W
166° W
164° W
162° W
160° W
158° W
156° W

Volcanoes on Stage

Essential Question: How does a Hawaiian volcano change as it ages?

Hawai`i DOE Content Standard

Science 8: Physical Earth and Space Sciences: Earth and Space Science - Forces That Shape the Earth

- Understand the Earth and its processes, the solar system, and the universe and its contents

Grade 4 Benchmarks

8.1 Describe how slow processes sometimes shape and reshape the surface of the Earth.

8.2 Describe how fast processes (e.g., volcanoes, earthquakes) sometimes shape and reshape the surface of the Earth.

Key Concepts

- Most Hawaiian volcanoes go through 10 stages beginning with the deep submarine stage and ending with a guyot.
- Stream/water, wind, and wave action on high islands will eventually erode all volcanic rock.
- The high volcanic islands slowly sink and erode away, and corals continue to grow, eventually forming atolls.

Activity at a Glance

Groups of students produce story boards and scripts that creatively depict the stages of Hawaiian volcanoes.

Time

3 - 4 class periods

Assessment

Students glue 10 volcanic stage cards in sequence from youngest to oldest onto a strip of oak tag board and provide labels and captions that describe:

- How the surface of the Earth is shaped and reshaped through slow processes (e.g., waves, wind, water, ice).
- How fast processes have shaped and reshaped the Hawaiian Islands.

Rubric

Advanced	Proficient	Partially Proficient	Novice
Use evidence to explain how slow processes have shaped and reshaped the surface of the Earth.	Describe how the shaping and reshaping of the Earth's land surface is sometimes due to slow processes.	Provide examples of the shaping and reshaping of the Earth's land surface due to slow processes.	Recognize that the shaping and reshaping of the Earth's land surface is sometimes due to slow processes.
Use evidence to explain how fast processes have shaped and reshaped the surface of the Earth.	Describe how the shaping and reshaping of the Earth's land surface is sometimes due to fast processes.	Provide examples of the shaping and reshaping of the Earth's land surface due to fast processes.	Recognize that the shaping and reshaping of the Earth's land surface is sometimes due to fast processes.

Source: `Ōhia Project © Bishop Museum/Moanalua Gardens Foundation

Vocabulary

shield-building – formation of a gently sloping volcano in the shape of a flattened dome that is built almost exclusively of lava flows

capping – stage in the evolution of a typical Hawaiian volcano during which rocks build a steeply, sloping cap on the main shield of the volcano. Eruptions are less frequent, but more explosive. The summit caldera may be buried.

erosion – wearing away of the land by the action of water, wind, or ice

secondary activity – also referred to as "rejuvenation"; renewed volcanic activity that sometimes occurs after the bulk of the island is formed and the volcano has experienced considerable erosion

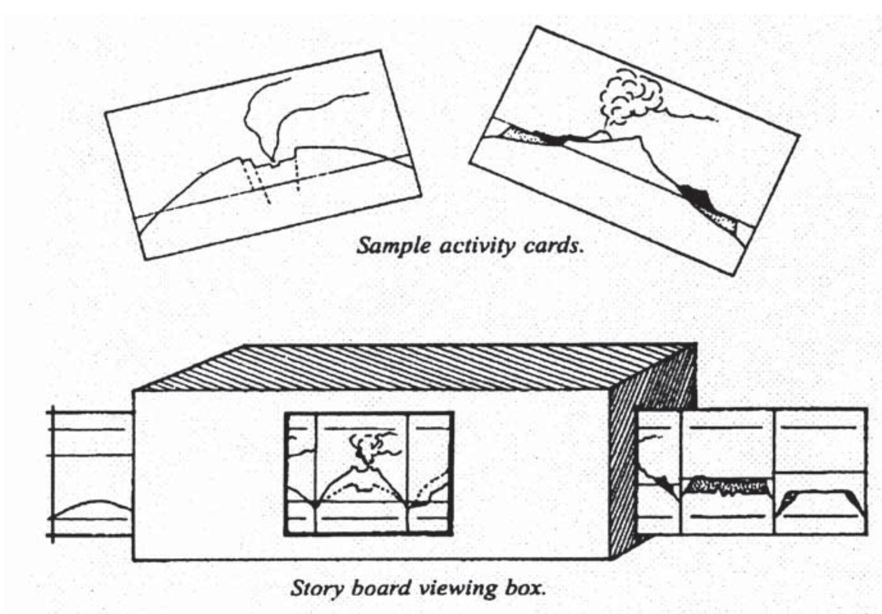
atoll – a ring-shaped coral reef or string of coral islands, usually enclosing a shallow lagoon

guyot – a flat-topped submerged seamount

Definitions adapted from: http://volcano.und.nodak.edu/vwdocs, www.soton.ac.uk/~engenvir/glossary.html, and www.nationalgeographic.com/wildworld/glossary.html

Materials

- student activity cards (provided)
- student data sheet (provided)
- maps of the Hawaiian Islands
- scissors
- color markers
- staplers
- shoe box
- 2 large sheets of oak tag board
- glue or rubber cement
- transparent tape



Sample activity cards.

Story board viewing box.

Advance Preparation

Make a story board viewing box. Duplicate and cut out a set of student activity cards. Cut a narrow slit on each side of a shoe box or use a poster board. The slits should be slightly taller than the cards. Cut window in the front of the box large enough for one activity card to show through and at the same level as the slits on the sides of the box. Create a story board by gluing the volcanic stages cards (in correct sequence beginning with the submarine stage) onto a strip of oak tag. Allow a 15 cm (6 in) space at the beginning of the story board as a leader. (See illustration of story board viewing box above.) Copy a student activity sheet for each student.

Background Information

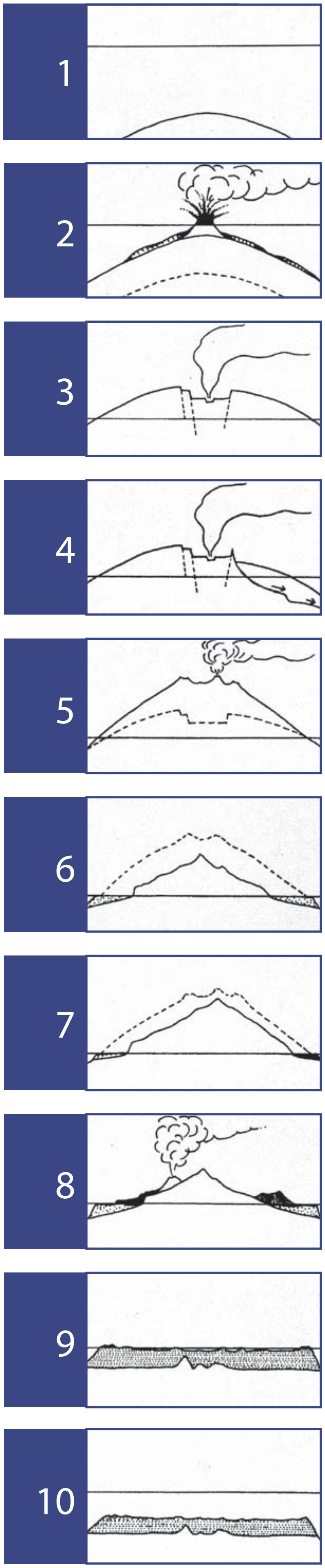
Island Ages

Compared to the 4.5 billion year-old Earth, the Hawaiian Islands are very young. Kaua`i emerged above the ocean surface only about 5 million years ago. Kure, the oldest island in the Northwestern Hawaiian Islands, is about 27.7 million years old. Beyond Kure is a chain of seamounts beneath the ocean surface. The oldest Emperor Seamount may have been a high volcanic island approximately 75 million years ago.

The approximate ages of volcanoes on the main Hawaiian Islands are listed on the student data sheet that accompanies this activity. The youngest of the volcanoes, Lō`ihi, is still approximately 950 m (3,000 ft) below sea level. It will most likely be thousands of years before Lō`ihi emerges to form the next Hawaiian island.

Volcanic Stages

Most Hawaiian volcanoes progress through a series of stages, including shield-building, cap formation, erosion, and rejuvenation. Hawaiian volcanoes typically pass through ten stages, although the erosion, reef growth, and rejuvenation, or secondary activity phases, occur simultaneously. Present landforms provide examples of these stages.



Stages	Examples in present landforms
1. Deep submarine	Lō`ihi
2. Shallow submarine	Lō`ihi in thousands of years
3. Shield-building	Kilauea and Mauna Loa
4. Landslide	Cliffs, like Pali on O`ahu or North Shore Moloka`i
5. Capping	Mauna Kea
6. Erosion	Kohala, W. Maui, E. Moloka`i, Ko`olau, Wai`anae, Kaua`i, Lāna`i
7. Reef growth	W. Maui, E. Moloka`i, Ko`olau, Wai`anae, Kaua`i, Lāna`i
8. Rejuvenation (secondary activity)	W. Maui, E. Maui (often referred to as Haleakalā), Ko`olau, E. Moloka`i, Kaua`i
9. Atoll	Kure Atoll, Midway (NWHI)
10. Guyot	many of the Emperor Seamounts

Hawaiian volcanoes do not necessarily go through all of these stages. The capping stage was skipped on the W. Moloka`i, Lāna`i, and Kaho`olawe volcanoes, and W. Moloka'i and Lāna`i have not experienced rejuvenation even though younger volcanoes have passed into this stage. Volcanic stages can be compared to young, middle-aged, or elderly people. A volcano has reached old age when the shield stops building and continues to erode. At this point, the volcano's smooth shield shape begins to "wrinkle" as streams cut into the shield's surface. It will continue to erode as the volcano matures.

From the study of Lō`ihi, scientists have discovered that a caldera may form when the volcano is still in the deep submarine stage and may be present throughout the shield-building stage as magma repeatedly withdraws and returns. A caldera is a crater more than 1.6 km (1 mi) in diameter that forms when the summit of a shield volcano collapses. During the main active shield-building stage, a caldera repeatedly collapses as magma withdraws, and refills as eruptions occur within it. However, some of our shield volcanoes have no visible caldera. Any evidence of calderas on the W. Moloka`i volcano or Hualālai on Hawai`i has been obscured by erosion or burial.

Landslide Stage

Until a few years ago it was believed that erosion from rain and wave action was the primary destructive force in the aging of our Hawaiian volcanoes. Recent discoveries from sonar views of the sea floor around our islands have shed some fascinating new light on our volcanic past.

Recent sonar "pictures" have revealed vast talus (broken rock) deposits off shore of most of the high sea cliffs in the Hawaiian chain. These deposits, frequently at 5,488 meters (18,000 ft) depth in the trenches that parallel the island chain, are the result of great landslides that carried away up to a third of the above-sea-level mass of some of our shield volcanoes. Most of these slides probably occurred early in the final stages of the shield's building and, in some cases, capping phase. (For more information about these giant landslides, visit the Moanalua Gardens Foundation web site at mgf-hawaii.com.)

Capping Stage

The capping stage may occur when a volcano begins to move off the hot spot. At this time, less frequent and more explosive eruptions produce ash or cinder cones and viscous, slow-moving lava that builds up a steep-sided bumpy cap on top of the volcano. The viscous, alkalic capping lava is due to the nature of the hot spot. If you consider the hot spot as a cylindrical body of hot mantle material, rising due to buoyancy, the central part rises faster and the outside material rises more slowly. The faster the mantle material rises, the more it experiences rapid decompression and the greater the amount of melting that occurs. This produces the tholeiitic composition of the main shield-building stage lavas. On the edges of the hot spot, the material rises more slowly, melts to a lesser degree, and produces small volumes of alkalic lavas. These are the lavas that produce the bumpy surface of Mauna Kea on the island of Hawai'i, which exemplifies this stage of a shield volcano.

As a volcano moves away from the hot spot, it progresses through a series of stages including erosion and reef growth and, sometimes, rejuvenation.

Rejuvenation (Secondary Activity) Stage

Rejuvenation (renewed volcanic activity) sometimes occurs after the bulk of the island is formed and the volcano has experienced considerable erosion. Cones produced during this secondary activity are similar to the cones built along rift zones during shield building. Well-known examples of rejuvenation include Le`ahi (Diamond Head) Crater and Hanauma Bay on O`ahu, and Kilohana Shield on Kaua`i.

Scientists are unsure why older, eroding volcanoes become active again. The rejuvenation typically occurs after the plate has carried a volcano approximately 150 km (90 mi) away from the hot spot.

Weathering and Erosion

Shield building ceases as a volcano moves off the hot spot, and weathering and erosion continue the slow process of wearing the island down. Erosion is the gradual wearing away of earth by water, wind, and ice. Hawaiian shield volcanoes are composed primarily of basalt, which is easily broken down by roots, wind, and rain. Streams are the primary source of erosion in Hawai`i. Over millions of years, streams carve valleys out of the slopes of shield volcanoes and gradually carry bits of rock to the sea. Stream action, combined with the forces of waves, wind, and the gradual sinking of the islands, eventually reduces shield volcanoes to small lava remnants, like Mokumanamana (Necker Island) in the northwestern part of the island chain.

The Final Stages

Gradually all traces of basalt are submerged beneath the sea and an island becomes an atoll—a lagoon with a fringing reef. But the island's story is not complete until the land is submerged beneath the sea. The movement of the plate eventually carries the atoll into colder water where the coral cannot survive. When the coral dies, only a guyot (a flat-topped submerged seamount) remains of the former high volcanic island.

Teaching Suggestions

1. Ask students to think like a detective and make a list of questions they would ask or observations they would make to discover the life history of a landform such as Diamond Head. For example: What is it made of? If it is layered, which layers came first, i.e., which layers are older? What has happened to it since it was formed?

2. Have students look for evidence of different landforms in their neighborhood. Discuss possible ways these features were formed.

3. Ask students to guess the age of their home island. Write their guesses on the board. To help them put the age of the island into perspective, compare the age of the Earth (4.5 billion years) to a nine-month school year. With this scale, each one million years would be equal to 1 hour and 24 minutes. Refer to the student data sheet and ask students to compute an average age for the island and use the "school-year" scale to figure how old their island would be. (O'ahu would be 4-5 hours old.)

4. Discuss the age of the main Hawaiian Islands compared to the age of the Earth. Help students to understand that the Islands are relatively young and that their growth through volcanic eruptions is a fast process. Compare this to the relatively slow processes (subsidence and erosion) that cause the islands to gradually decrease in size. Conduct a discussion about the island stages using the following questions:

   <u>Discussion Questions</u>
   - Do you think islands have a life cycle like living things do? What processes cause them to grow up? What processes cause them to age and decrease in size?
   - Where is the youngest of the Hawaiian volcanoes forming? (On the ocean floor south of Hawai`i Island.)
   - What is the difference in age between Mauna Kea, which is 400,000 years old, and the oldest volcano that is still above sea level—Kure Atoll, which is about 30 million years old? What are the slow processes that changed Kure from a tall volcano to a flat atoll?

5. Distribute the student activity sheet of 10 volcanic stages and have students cut the stages out and arrange them in the order that they believe shows the stages of the youngest to the oldest volcano. (See Extended Activities for information about the Exploring the Islands telecast that supports this activity.)

6. Check students' arrangement of their cards and then work with them to arrange the stages in the correct sequence.

7. Place the story board viewing box in front of the class. Demonstrate how the sample story board was made and pull it through the opening in the box.

8. Distribute the student data sheet. Working individually or in groups, have students pick one volcano to be the subject of their story board. Use a map of the Hawaiian Islands and have students locate their volcano on the map. For additional background information on each island include pages 1-12 from The Hawaiians of Old (Dunford, Betty. 1987. The Hawaiians of Old. Bess Press, Honolulu, HI).

9. If working in groups, students can divide tasks of writing the script and illustrating one of the volcanoes. All story boards should depict current stages of volcanoes accurately but creative art and writing skills should be encouraged! Help students see how a volcano could take on a personality as it matures from infancy through adolescence, maturity and old age.

10. Ask students to put their volcanoes on stage and present their story boards to the class. Presenters can omit the volcano's name and see if others can determine the identity.

11. Give a 9" x 12" sheet of construction paper or oak tag sheet to each student. Have students glue the volcanic stage cards in order from youngest to oldest on the large sheet. Ask them to label each stage and write a descriptive sentence under each picture. Their descriptions should distinguish between the relatively fast processes describing how the volcanoes formed, and the slow processes describing how waves, wind and water have changed the surface of the islands over time.

Extended Activities

Tune into the Exploring the Islands Telecast: "Volcanoes on Stage" to provide students with additional information to support this activity. During the telecast, students from Liholiho Elementary School visit the southeast shoreline of O'ahu where they meet an "old volcano" who shares stories about his life with them. Students model the stages of a Hawaiian shield volcano in sand and put on a volcano skit about the "life" of a shield volcano. Dr. Alex Malahoff dives in a submersible craft over Lō'ihi, Hawai`i's youngest volcano, and looks through the eye of a camera to see strange geologic formations, steaming vents, and living things new to science. In class, students sequence volcanic stages cards as the show progresses. For information about air dates and ordering a tape of the program, see the DOE Teleschool Web site at: http://www.mgf-hawaii.com/HTML/Television/distancelearning.html

Read the book, How Much Is a Million? (Schwartz, David M. 1985. How Much Is a Million? Lothrop, Lee and Shepard Books.) Compare the ages of the Islands to the examples in the book.

Have students use the activity cards to make volcano flip booklets.

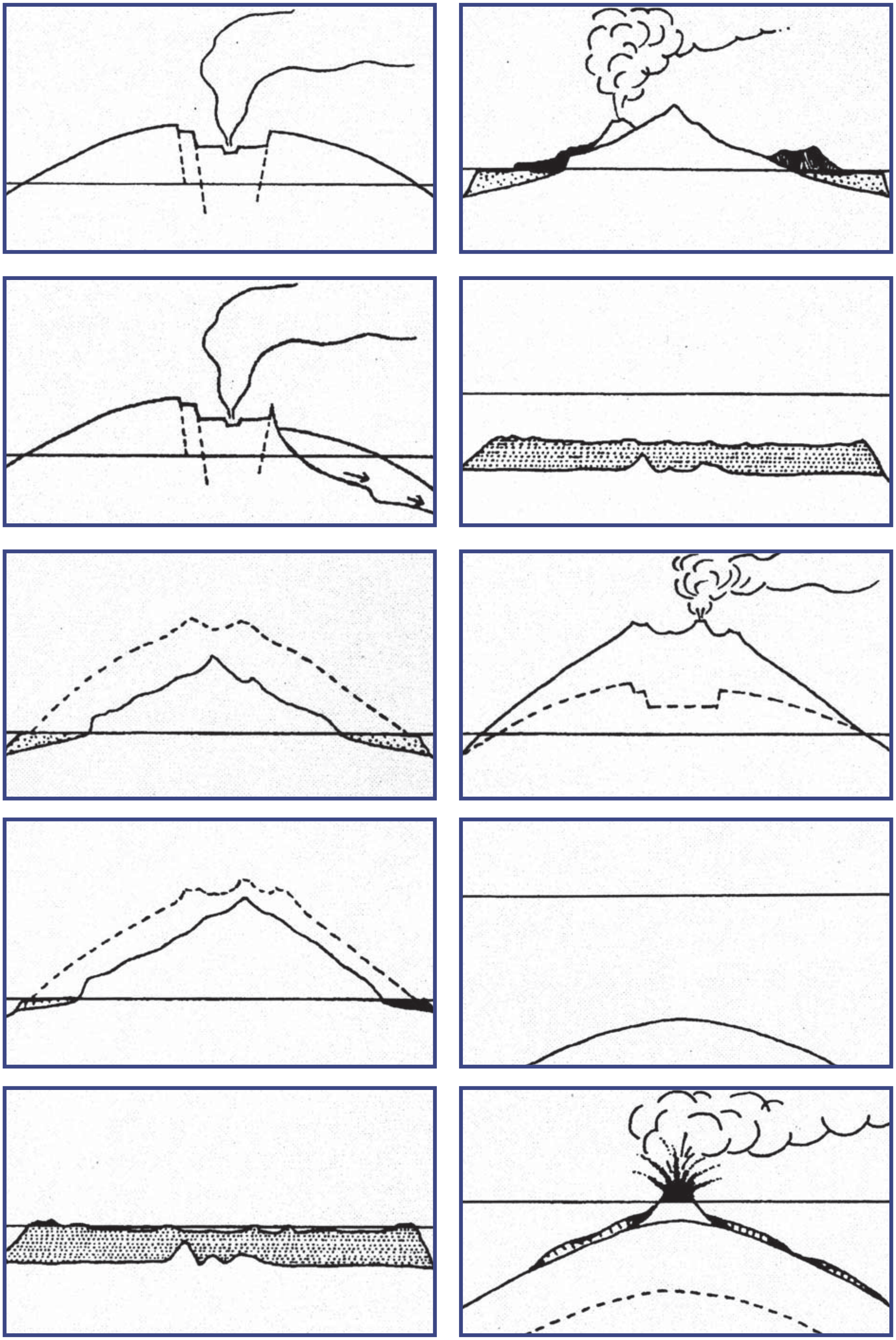
Each group of students could use creative dramatics to demonstrate the stages of a volcano on one of the Islands. Using hand and arm motions, students could demonstrate magma rising and a shield shape being created. They could drop arms to depict the collapse of the caldera and then create a bumpy cap with their hands. They could sink to the floor as erosion occurs and another group of students could "swim" to the island and join hands to form a coral reef around it.

Students could develop a time line depicting the ages of the main Hawaiian Islands. The time line could be created with string and a paper tag label for each island. Students will need to experiment with various scales until they can represent millions of years in a manageable space! If a scale of 1 m equals 100,000 years were used, a time line including Kaua`i would stretch 47 m (154 ft)! The time line could be laid out in the schoolyard or in the cafeteria and shared with other classes.

Some of the volcanoes in Hawai`i have not exactly followed the stages as shown in the volcanic stages cards. The W. Moloka`i volcano skipped the capping stage. And even though younger volcanoes have had secondary activity, Lāna`i and W. Moloka`i have not!

Volcano	Approximate Age (millions of years)	Current Stage
Lō`ihi	still forming	submarine
Kīlauea	still forming	shield building
Mauna Loa	still forming	shield building
Hualālai	may still be forming	capping
Mauna Kea	0.4	capping
Kohala	0.5	capping
E. Maui (Haleakalā)	0.7	rejuvenation (secondary activity)
Kaho`olawe	1.0	rejuvenation (secondary activity)
W. Maui	1.0	rejuvenation (secondary activity)
Lāna`i	1.5	erosion
E. Moloka`i	1.5	rejuvenation (secondary activity)
Ko`olau	2.5	rejuvenation (secondary activity)
Wai`anae	3.5	rejuvenation (secondary activity)
Kaua`i	4.7	rejuvenation (secondary activity)
Nihoa	7.2	erosion
Midway	27.7	atoll

1. Locate the island your group has selected on a map of the Hawaiian Islands. How many volcanoes are on your island? Find the volcanoes on the list above.
2. Use the information on this sheet and your knowledge about volcanoes to make a paper story board showing the stages of one of the volcanoes on your chosen island.
3. Be creative with your story! You could try comparing the volcano to a human. Is your volcano in infancy, childhood, adolescence (teenage), middle or old age? Give the volcano a personality and write a script that will give your classmates clues to the volcano's identity.



Source: `ōhī`a Project © Bishop Museum/Moanalua Gardens Foundation

Wayfinding

Essential Question: What do wayfinding and voyaging reveal about Hawaiian culture and the ability to navigate to distant islands?

Hawai`i DOE Content Standard

Social Studies 6: Cultural Anthropology: Systems, Dynamics, and Inquiry - Cultural Systems and Practices

- Understand culture as a system of beliefs, knowledge, and practices shared by a group and understand how cultural systems change over time.

Grade 4 Benchmark

4.6.1 Explain how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.

Nā Honua Mauli Ola #1- 8

Incorporate cultural traditions, language, history, and values in meaningful holistic processes to nourish the emotional, physical, mental/intellectual, social, and spiritual well-being of the learning community that promote healthy mauli (life, spirit) and mana (divine power).

- Learners are able to understand and appreciate the importance of Hawaiian cultural traditions, language, history, and values.

Key Concepts

- Pacific navigators have a close relationship to the natural world and are highly skilled at wayfinding—the art of using stars, ocean swells, clouds, winds, and seabirds to navigate to distant islands.
- Practicing Hawaiian values such as laulima (working together), kuleana (taking responsibility), and mālama (caring) is essential to successful voyaging.

Activity at a Glance

Students read about voyaging and play a game in which they become voyagers on a canoe trying to reach a distant island.

Time

3 class periods

Assessment

Students:
- Illustrate a traditional voyaging canoe and the wayfinding clues that the ho'okele (navigator) uses to find distant islands.

- Write a journal reflection describing: a) what it would be like to be part of the crew in a long voyage (select one of the roles from the kuleana reading and write from that perspective; and b) values and behaviors that would be critical for voyaging survival, and how those values and behaviors are also critical for surviving on islands.
- Describe how the canoe, traditional wayfinding, and values are elements of Hawaiian culture and contribute to the preservation of culture.

Rubric

Advanced	Proficient	Partially Proficient	Novice
Analyze how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.	Explain how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.	Explain that language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.	Explain, with assistance, how language, traditional lore, music, dance, artifacts, traditional practices, beliefs, values, and behaviors are elements of culture and contribute to the preservation of culture.

Vocabulary

ho`okele – navigator
kuleana – responsibility
laulima – working together
mālama – to care for
navigate – to steer a course
wayfinding – the art of navigating without instruments, using clues in the environment

Materials

- Navigating Change video segment: "The Voyage" (provided)
- 2 student readings (provided)
- chance cards (provided)
- canoe cut-out (provided)
- box of paper clips or other small tokens
- index cards
- drawing paper
- scissors
- colored markers

Advance Preparation

Make a copy of the student readings on voyaging and the canoe cut-out for each student. Copy, cut, and laminate the chance cards.

Background Information

Pacific navigators are highly skilled at wayfinding—the art of navigating without instruments. Having perfected this art, they were able to guide voyaging canoes across vast distances in the Pacific, using only their minds and a keen sense of nature to guide them. At night, wayfinding involves knowing the patterns of stars and using the stars and the moon as a map to stay on a course. During the day, the navigator observes the ocean swells at sunrise and sunset and uses the swells to guide the canoe when the sun is too high in the sky to provide direction. Navigators are in tune with the stars, the winds, the swells, the moon, and the habits of seabirds. The amazing long distance voyages that have been carried out by Pacific islanders testify to the outstanding achievements of the ho`okele (navigators) and the voyagers who sailed the wa`a kaulua (double-hulled canoes).

The voyagers on a canoe each have a kuleana (responsibility) that is vital to the success of the voyage (see student reading "Kuleana of Hōkūle`a Crewmembers"). During a voyage, crewmembers become an `ohana (family) living together in very close quarters with limited resources. They laulima (work together) and mālama (care for) each other and the canoe. The assessment activity for this lesson asks students to consider the importance of these values for surviving on canoes as well as for living on islands. Like voyagers on a canoe, islanders have finite resources and we need to work together to care for those resources and for one another. As students continue on the voyage of Navigating Change they will explore ways to make this vision a reality.

Teaching Suggestions

1. If you have not already done so, show the first Navigating Change video segment, "The Voyage."

2. Discuss what students learned from the video.
   <u>Discussion Questions:</u>
   - How are the NWHI different from the main Hawaiian Islands?
   - What is the purpose of the Hōkūle`a voyage to the "kūpuna" islands?
   - What do you think it might be like to be part of the crew on a voyage?
   - How do you think Hawaiian navigators find distant islands using only clues in nature?

3. Distribute the "Wayfinding" student reading to each student. Have students take turns reading aloud.

4. Discuss the reading.
   <u>Discussion Questions</u>
   - How are voyaging canoes and wayfinding an important part of Hawaiian culture?
   - What do you think are the most important clues that a navigator uses in wayfinding? Why?
   - How do voyagers help one another during a voyage?

5. Distribute index cards and ask each student to develop two questions related to the content of the reading (one on wayfinding and one on life on board). Have them write a question and the answer on each card. Explain that these cards will be collected the following day and used as voyaging cards in a wayfinding game with the class.

6. Conduct the wayfinding game (see instructions at the end of this activity).

7. Discuss what students learned from the game.
   Discussion Questions
   •What was the most challenging part of the voyage?
   •How were the chance cards similar to what might really happen on a voyage?
   •If you sailed 1,200 miles northwest of the main Hawaiian Islands where would you end up?
   (Kure atoll at the end of the NWHI chain)

8. Distribute the reading, "Kuleana of Hōkūle`a Crewmembers" and ask students to read it as homework and complete the journal reflection and drawing assessment activities.

9. Ask students to share some of their writing and illustrations. How do they compare living on a canoe with living on an island? Discuss how values and practices related to wayfinding and voyaging are an important part of Hawaiian culture.

10. Have students complete their culminating journal projects. (See student assessment in the Unit Overview.) Encourage students to share their journal entries with their classmates and compare what they "saw" on their imaginary voyages.

Extended Activities

Take the students on a field trip through the Hawai`i Maritime Center on O`ahu or to the halau wa`a of the voyaging canoe on your island to learn more about voyaging. For information contact:

- Nā Kalai Wa`a Moku o Hawai`i, Kamuela, Hawai`i 808/885-9500
- `Aha Pūnana Leo, Hilo, Hawai`i 808/966-5453 Chad Kalepa Babayan, Maile Enos
- Hui o Wa`a Kaulua, Lāhina, Maui 808/667-4050
- Hawai`i Maritime Center: http://www.bishopmuseum.org/exhibits/hmc/hmc.html808/523-6151.
- Polynesian Voyaging Society, Honolulu 808/536-8405
- Friends of Hōkūle`a and Hawai`iloa, Honolulu 808/843-8414
- Nā Kalai Wa`a Moku o Kaua`i, Lihu`e, Kaua`i 808/245-8555 Dennis Chun

Challenge students to use a measuring tape and chalk to draw an outline of the Hōkūle`a voyaging canoe on a large outdoor surface (basketball court or playground). The canoe is 17'6" wide and 62'4" long. Have them outline the deck, which is located on top of the hulls and is about 9' by 50'. (See picture of the canoe on the Student Reading provided with this activity.) Ask 12 students to assemble on the deck and imagine spending an entire voyage in such a small area. Discuss the values that would be critical to working together in the confined space of the canoe.

References

Pukui, Mary Kawena. (1983) `Ō lelo No`eau: Hawaiian Proverbs and Poetical Sayings. Honolulu, HI: Bernice P. Bishop Museum Special Publication No. 71. Bishop Museum Press.

Yadao, Elisa. "Daily Living aboard Hōkūle`a." Education Kit: Navigating Change. Hawai'i: PREL, State of Hawai'i Department of Education, Department of Land and Natural Resources, NOAA, U.S., Fish & Wildlife Services, and Bishop Museum.

Wayfinding Game Instructions

Objective: To reach an imaginary island 1,200 miles away before the food supplies run out on the canoe.

Game Materials

- voyaging cards (created by students)
- chance cards (provided)
- canoe cut-outs (created by students)
- box of paper clips or other small tokens

Introduction

Invite students to go on an imaginary voyage to find a distant island 1,200 miles to the northwest. Their canoes should travel 200 miles per day if they are able to find their way (by answering voyaging questions correctly). On board each of their canoes they have enough food and water for an 8-day voyage (2 extra days). Each turn represents a day, so they have 8 turns to reach their destination before their water and food run out.

Pre-game Preparation

- Select voyaging cards from those that students have created (eliminate cards that ask for the same information).
- Give a canoe cut-out sheet and scissors to groups and ask each to create a cut-out of their voyaging canoe and give it a name.
- Draw a voyaging line on the board to represent 1,200 miles. Mark the line with six 200-mile increments to indicate a voyaging "day."

To Play

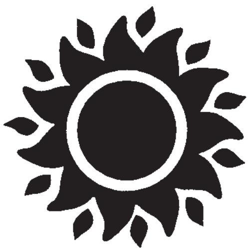
1. Voyagers tape their canoes to the board at the beginning of the voyaging line. The canoes will be sailing along the line (the course) to find the island 1,200 miles away.
2. Voyagers take turns answering a question on a voyaging card. (Teacher draws and reads card to class.) The crew consults and agrees on an answer within 60 seconds. If a correct answer is given, the canoe travels 200 miles along the voyaging line.
3. If a canoe crew answers a question incorrectly, they fail to find their way and will not move forward. In addition, they must draw a chance card and follow the directions on the card.
4. Each canoe crew receives 8 food/water tokens (paperclips or other items). Each token represents food and water supply for one day. Once a turn is taken, a day is over and the crew hands in one token. If all food and water tokens are used before the canoe reaches the island at the end of the 1,200-mile course, the canoe is out of the game.

To Complete the Voyage

If the voyagers "sail" 1,200 miles (answer at least 6 voyaging cards correctly) before they run out of food and water, they reach the island and successfully complete the voyage!

SKY

Sun: The sun rises in the east and sets in the west. The path the sun creates on the water at sunrise and sunset helps the navigator establish direction.



Ulu o ka lā.
The sun grows.

Said of the light of sunrise just as the sun's rim touches the horizon. The morning sun is used for navigation to determine the primary direction of east. `Ōlelo No`eau #2870

Stars: Most stars rise in the east and set in the west. Navigators use stars to establish direction.

High clouds: High clouds that stay in one place are a clue to locate an island. The clouds build up over a high island and stay there. When there are no islands nearby, the clouds move with the direction of the wind.

Cloud colors: When a cloud has a light green color on its underside it could be a clue that land is near. Clouds reflect the light green color of shallow water around an island. Low islands can be seen at sea from about 7 to 10 miles away.

WIND

Winds affect speed and direction. Navigators estimate the speed of the wind. They also figure out the direction that the wind is coming from to help them stay on course.

SEA

Ocean swells: Ocean swells are usually powered by prevailing winds and can be used to determine direction. When the pitch and roll of the canoe changes, it means the canoe is changing direction.

Small waves: When swells come in contact with land they are reflected back out to sea. This creates turbulence or small waves coming from a particular direction that hit the canoe. This is a clue that land is near.

Water colors: Deep water is usually blue. A greenish color water indicates reefs and shallow water.

Ke kai lipolipo polihua a Kāne.
The dark-blue ocean of Kāne.

The deep sea out of sight of land. `Ōlelo No`eau #1729

ANIMALS

Seabirds: Seabirds such as the manu-o-Kū (white tern) and the noio (noddy tern) fly out to sea during the day to catch fish. They return to land to rest in the evening. By following the direction that the birds fly in the evening, navigators can aim toward land. These birds are usually seen when the canoe is within 100 miles of the island. If voyagers spot the `iwa bird it's not a sure sign that land is near. The young nomadic `iwa birds will stay at sea for long periods of time. The `iwa can help the navigator to predict the weather before heading out to sea as it prefers favorable wind conditions to be able to lift and soar.

Lele ka `iwa mālie kai ko`o.
When the frigate bird flies out to sea, the rough sea will grow calm.

A weather sign. `Ōlelo No`eau #1979

Floaters: Other signs of land are driftwood, seaweed, animal life, or rubbish in the sea. When voyagers get close to land, the amount of "floaters" in the water increases.

VOYAGING ON HOKŪLE`Ā

Hawaiians ceased long-distance, open-ocean voyaging centuries ago, so there were no examples of actual ancient voyaging canoes as models for the voyaging canoe Hōkūle`a. Hawaiian artist Herb Kāne based the design of Hōkūle`a on drawings of canoes made by artists and draftsmen employed by Captain Cook and other early explorers of the Pacific. Hōkūle`a is much smaller than the 100-foot-plus Polynesian canoes seen by early European visitors. It was completed in 1975. It has:

- two 62-foot hulls
- eight `iako (crossbeams) joining the two hulls
- one pola (deck platform) lashed to the crossbeams between the two hulls
- rails along the decking
- two masts

Hōkūle`a: Star of Joy

The canoe was named for the star Hōkūle`a (Arcturus), the brightest star in the northern hemisphere. "Hōkūle`a" means "star of joy" or "clear star." This star is the zenith star of Hawai`i, which means it passes directly overhead in the night sky. It is a fitting name for the canoe, for the star may have been a guide star for navigators returning to the Islands from long voyages to the South Pacific.

Daily Living aboard Hōkūle`a

“Once you go on the canoe, because it’s so small (40 square feet), you try to make it like one family.” —Snake Ah Hee, a 30-year veteran crewmember of Hōkūle`a.

Sleeping Quarters: Sleeping quarters are tight. Individual spaces measure about six feet in length and three feet across. The sleeping areas are on both sides of the deck and are covered with canvas. Usually two crewmembers are assigned to each bunk. One person sleeps while the other stands watch. Personal belongings are stowed here. Each crewmember is allowed one 48-quart cooler. Beds are simply a board placed over the coolers, covered by a sleeping pad.

Bathroom Facilities: Going to the bathroom involves strapping a safety harness over your shoulders, hooking the harness to a safety line, and then leaning overboard to relieve yourself. Bathing is done either forward or aft of the canoe. Forward, you sit in a net slung between the two canoe hulls. Aft, you bathe in an open compartment, pulling saltwater up in a five-gallon bucket. You use a special sea soap, which makes bathing in saltwater refreshing. Because the canoe is so small, privacy is limited. But all crewmembers respect the needs of others. A curtain provides privacy for those going to the bathroom and bathing.

Cooking: Cooking is done in the center of the canoe. The galley, or kitchen, is a two-burner propane gas stove in a metal box. Once fresh food runs out, most of the food on board comes out of a box or can. Fresh fish caught by the crew adds to the food supply. Each voyage has a designated fisher, 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. Mealtime is one of the few times during the day that the entire crew is together on deck. On long days, meals are a highlight. When the weather is cold and rainy, a hot meal can do wonders.

Water: 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. Crewmembers also store rain water for cooking and bathing.

Free Time: When crewmembers 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 it usually doesn’t. Being away from home for a long time can cause homesickness, especially for the new crew members. Older crewmembers help them to get through these times.

Sources: Adapted from Yadao, Elisa. “Daily Living aboard Hokule`a.” Education Kit: Navigating Change. Hawai’i: PREL, State of Hawai`i Department of Education, Department of Land and Natural Resources, NOAA, U.S., Fish & Wildlife Service, and Bishop Museum.

Kuleana of Hōkūle`a Crewmembers   Student Reading

To ensure that the canoe sails safely and efficiently, each person has a kuleana (responsibility). Both men and women can hold the positions. In the event of bad weather or an emergency, all of the crewmembers are expected to work together. The crew members function like an `ohana (family).

All jobs on the canoe are important to the safe sailing of Hōkūle`a. A crewmember's most critical responsibility is to realize that everyone depends upon him/her to carry out assigned duties and to work well as part of a team.

Sailmaster

The sailmaster carries the overall responsibility for the canoe and crew. The sailmaster serves primarily as an advisor. The sailmaster has the final say on the canoe's sailing course and on all canoe operations. He or she consults with the navigators and captain.

Ho`okele (Navigator)

The navigator determines the canoe's course, sets the sailing strategy, and determines the direction in which the crew will sail Hōkūle`a. He or she must stay oriented at all times. This means that generally he or she 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, sitting 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.

Captain

The captain's primary responsibility is safety. He or she ensures that a capable well-trained crew is on board and that the canoe is well maintained. The captain is responsible for training the crew and preparing the canoe for the voyage. He or she makes sure that sails are mended, that Hōkūle`a is cleaned and painted, and that the food, water, and safety gear are on board. At sea, the captain executes all sailing decisions. Once the navigator sets the sailing strategy, the captain directs the crew to hoist, drop, or change sails. The captain coordinates activities with the escort vessel and provides a daily work schedule for the watch captains. The captain decides when and if to ration food and water.

Watch Captains

The watch captains direct crewmembers and carry out instructions from the captain. The watch captain makes sure that his/her crew is up and on duty for its watch. He or she assigns steering positions to crew, goes through the safety checklist, and maintains a watch log. The watch captain is responsible for maintenance of the canoe during the watch, including cleaning up after meals. Additionally, the watch captain is responsible for monitoring the safety, health and morale of his/her crew.

Medical Officer

The medical officer is a certified doctor that is aboard Hōkūle`a for each long voyage. Her/his primary kuleana is the health of the crew. The medical officer makes sure 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 attends to the crew's heath and medical needs on shore.

Radio Operator

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

Carpenter

A designated carpenter oversees all repairs done on the canoe. The carpenter also maintains the tool inventory.

Electrician

An assigned electrician maintains all electrical systems.

Cook

The cook plans the canoe's menus and does most of the cooking. The ability of the cook affects the crew since meals are the highlight of each day. Good nutrition is also important for maintaining the health of the crew.

Quartermaster

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

Fisher

Fishing off of the canoe is an important job. One crewmember 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

Documentors keep historical records of the voyage by writing and recording video and audio taping.

Safety Officer

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 safety gear the canoe carries. In addition, all crewmembers must be trained in man-overboard and fire procedures.

Source: Adapted from Yadao, Elisa. "Daily Living aboard Hokule`a." Education Kit: Navigating Change. Hawai`i: Prel, State of Hawai`i Department of Education, Department of Land and Natural Resources, NOAA, U.S., Fish & Wildlife Service, and Bishop Museum.

Chance Cards

There is no wind today. Lose 100 miles on your voyage.	Winds are favorable today. Gain 100 miles.
Your fisher catches a large ahi. Receive an extra food/water token.	Your canoe hits a shallow reef. You damage one of your two hulls. Lose 100 miles on your voyage as you take time to repair it.
The mast on the canoe breaks in high wind. Lose 100 miles as you take time to repair it.	The quartermaster did an outstanding job at distributing the weight on the canoe. Gain 100 miles.
Man overboard! Lose 100 miles as the crew works to rescue the crewmember.	You come across a monk seal entangled in a fishing net. You stop to help. Lose 100 miles.
A fierce storm sets your canoe off course. Lose 100 miles.	High winds tore one of your sails. Lose 100 miles as you take time to repair it.

Chance Cards

The ho`okele falls asleep.

The canoe gets off course.

Lose 100 miles on your voyage.

You have a clear starry night and good wind.

Gain 100 miles.

You are approaching a heavy storm. The sailmaster suggests going around it for safety reasons. Your navigator agrees.

Lose 100 miles to go around the storm.

You need to tack (follow a zig-zag course) as you sail into the wind.

Lose 100 miles on your voyage.

Seabirds lead you to a good fishing area. Everyone works together to haul in a big tuna.

Gain a food/water token.

You catch lots of rainwater to use in cooking.

Gain a food/water token.

A huge wave knocks a food container overboard.

Lose a food/water token.

Heavy fog! You lose sight of the stars and get a little off course.

Lose 100 miles on your voyage.

A steering paddle breaks in heavy seas.

Lose 100 miles as you repair it.

You see high clouds at a distance. You just discovered an uncharted island. You are off course!

Lose 100 miles on your voyage.

Land to Sea Connection

Pōhai ka manu maluna, he i`a ko lalo.

When the birds circle above, there are fish below.
—Mary Kawena Pukui, `Ōlelo No`eau #2667

Land to Sea Connection

Seabirds flying back and forth between the land and sea are a visible link of the land to sea connection. They are a vital part of the circle of life, enriching nearshore waters with nutrients from their guano and helping to maintain balance in the reef ecosystem that sustains them. Like the seabirds, each of us living on an island relies on the land to sea connection. Looking to the "kūpuna" islands, we can see these connections without all of the layers of human activities that tend to obscure our interdependence with the land and sea.

Northwestern Hawaiian Islands Ecosystem

The remote and relatively unknown Northwestern Hawaiian Islands (NWHI) include the northern three quarters of the Hawaiian archipelago, a two-million acre ecosystem of coral reefs, atolls, small islands, seamounts, banks, and shoals. Here, in a nearly balanced functioning dynamic between land and sea, millions of seabirds nest, thousands of sea turtle eggs hatch, an abundance of sharks and large predatory fish thrive, and thousands of marine species flourish. The relatively undisturbed coral reef habitat supports more than 7,000 marine species, one-quarter of which are endemic, which means they exist nowhere else on the planet.

Let's take a look at the land to sea connection by following a Hawaiian monk seal diving off one of the remote NWHI. In deep banks off the reef, the seal swims among colorful precious corals where strange-looking garden eels wait to ambush their prey. Schools of onaga and `ōpakapaka dwell in this pristine deep habitat along with large primordial-looking sharks. The seal rises near and observes a school of `ahi that chases its prey to the surface. Seabirds swirl and dart overhead, attracted to the small fish fleeing from the `ahi. The seal swims gracefully among the many species of corals that grow in the warm, clear, shallow water surrounding the island. Colorful and diverse marine life—invertebrates and fishes—abound here, supported by algae species that form the base of the food chain. The algae flourish in these waters that are enriched with nitrogen from seabird guano. In the shallow lagoon, the seal swims past resting dolphins and is shadowed by giant ulua before hauling out onto the beach to rest. On the beach, sea turtles bask in the sun and thousands of seabirds compete for nesting sites among the native plants. The loud calling of the seabirds provides a stark contrast to the silence of the deep sea banks. Here on this remote island we see an extremely healthy seabird nesting colony in harmony with the endemic plant community and the coral reef.

The 14 million seabirds that nest in the NWHI, the Hawaiian monk seals, and the green sea turtles all rely on healthy land and sea habitats. Hawaiian monk seals, with a population of only 1,400 seals, are critically endangered. These endemic mammals need protected beaches that provide them with critical resting and pupping areas. The remote beaches and healthy reefs of the NWHI are critical to the turtles as well. More than 90% of all green sea turtles in the entire Hawaiian archipelago return to the protected beaches of one atoll in the NWHI to nest.

NWHI Habitat Description

Terrestrial Habitat: The NWHI include about 3,524 acres of land. The habitat types vary from coastal dry shrubland on Nihoa, Mokumanamana (Necker), Laysan, and Lisianski to coastal dry grasslands and herblands on the smaller, lower islands of French Frigate Shoals and Pearl and Hermes Atoll. These vegetation types have become so rare on the main Hawaiian Islands that textbooks often use photographs of these islands to illustrate them. Nihoa Island, for example, is one of the most biologically pristine islands in the Pacific, and probably most closely represents the original island appearance and biota present before humans came to the Hawaiian Islands.

The low sandbar islets of French Frigate Shoals and Pearl and Hermes Atoll support very little vegetation. A few larger shrubs survive the rigors of winter wash-overs by storm waves and low soil moisture to become the prized nesting sites of red-footed boobies, black noddies, and great frigatebirds. Space is highly contested by the animals of the atoll, and breeding, feeding, and basking take place on three levels—in burrows, on the surface, and on top of and in the few shrubs available.

Reef and Nearshore Marine Community Habitat: The Northwestern Hawaiian Islands contain more reef acreage than all of the main Hawaiian Islands, as well as greater diversity in marine habitat (e.g., lagoon complexes and barrier reefs). Fringing reefs and atoll reefs surrounding shallow lagoons are extensive in the area and make up most of the shallow water marine habitat. Corals are the most conspicuous members of the reef community, although other organisms such as coralline algae, mollusks, echinoderms, and foraminiferans aid in the reef-building process. Coral reefs provide habitat, shelter, and food for thousands of marine species and provide valuable substrate or anchorage for the sandy islands or islets, the lifeblood support system for millions of seabirds, sea turtles, monk seals, and land-based endemic plants and insects.

The geological and biological characteristics of the nearshore marine community are intimately tied to the volcanic origin of the Hawaiian Islands, coral reef formation, and the northwestward movement of the Pacific plate. The emergent portion of all islands north of Gardner Pinnacles consists entirely of calcium carbonate deposited by coral reefs and associated marine organisms. Were it not for coral growth, these islands would have sunk at the latitude of Gardner Pinnacles millions of years ago. Instead, corals and other calcifying organisms have built reefs, which have kept pace with sinking and erosion of the volcanic islands.

Variations in coral species dominance do occur and some types of coral, such as the genus Acropora, are restricted to the center of the chain. The coral reefs offer a variety of habitat types, including fore and back reefs, lagoons, coral flats, banks, and shoals.

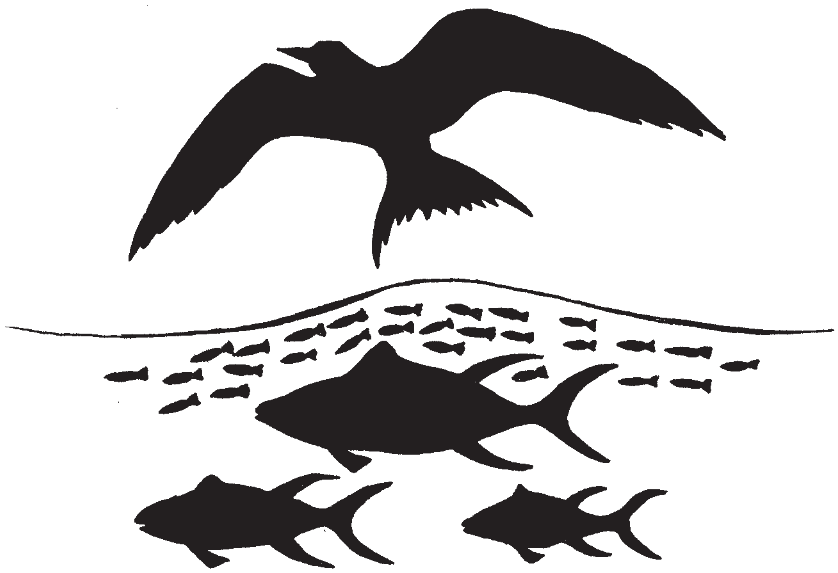
Endemism: The NWHI have one of the highest rates of endemism in the Pacific for marine and terrestrial species. Researchers estimate that these islands are home to many species that occur naturally nowhere else on the planet; these include 12 endemic species of plants, 7 endemic land mollusks, 64 endemic arthropods, and 4 endemic land birds. The species' distribution and habitat requirements make them very fragile and extremely susceptible to predation, over-harvesting, and being out-competed by alien species.



Hawai`i DOE Content Standards	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Science 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution Unity and Diversity	What roles do corals play in the coral reef ecosystem? Activity: Reef Builders	• Tiny animals called "polyps" construct corals. Most coral reefs are formed by many polyps living together in a colony. • Corals are both producers and consumers. They use their stinger-lined tentacles to capture tiny animals (plankton) that drift by in the currents. • Corals also obtain food through a unique relationship with single-celled algae that produces sugar through photosynthesis.	4.5.2 Describe the roles of various organisms in the same environment.
Science 3: Life and Environmental Sciences: Organisms and the Environment: Cycles of Matter and Energy Interdependence	How are different marine and reef organisms adapted to their environment and how are they dependent on one another for survival? Activity: Circle of Life	• Producers (algae, phytoplankton) provide oxygen and a source of food to marine animals. • Marine animals (consumers including the herbivores, omnivores, and carnivores) provide carbon dioxide and nutrients to the plants (producers). • The interdependence of producers, consumers, and decomposers creates a balanced ecosystem.	4.3.1 Explain how simple food chains and food webs can be traced back to plants. 5.3.2 Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter.
Science 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution Unity and Diversity Science 3: Life and Environmental Sciences: Organisms and the Environment Cycles of Matter and Energy Interdependence	How are Hawaiian monk seals, seabirds, and green sea turtles dependent on both the ocean and land habitat for their survival? Activity: Land to Sea Survival Shuffle	• Hawaiian monk seals, seabirds, and green sea turtles need both healthy land and sea habitats to survive, beaches are important resting places, and the sea provides a habitat for feeding. • Sharks, seals, seabirds, and sea turtles are part of a food chain where each organism is dependent on other organisms for food. • Human activities on beaches and marine debris in the ocean affect the survival of seals, turtles, and seabirds.	4.3.2 Describe how an organism's behavior is determined by its environment. 4.5.3 Describe how different organisms need specific environmental conditions to survive. 5.3.1 Describe the cycle of energy among producers, consumers, and decomposers.

Student Journal

Unit 2 – Land to Sea Connection



Pōhai ka manu maluna, he i`a ko lalo.

When the birds circle above, there are fish below.
—Mary Kawena Pukui, `Ōlelo No`eau #2667

Student's Name:____

School:____

Date started:____

Date ended:____

Student Assessment Overview

Unit Essential Questions

- What roles do corals play in the coral reef ecosystem?
- How are different marine and reef organisms adapted to their environment and how are they dependent on one another for survival?
- How are Hawaiian monk seals, seabirds, and green sea turtles dependent on both the ocean and land habitat for their survival?

How you will be graded for this unit:

Individual Journal

It is your responsibility (kuleana) to complete a journal for this unit. Following is a checklist of the pages you will need to include in your journal. Place this page in your journal and make a check next to each item when your complete it. You will be given more details during each lesson.

Journal Pages	Completed
Gr. 4	
Reef Builders – Standard: Science 5 • Describe the roles of the algae (zooxanthellae) and the coral in the coral reef environment. Writing should include how coral polyps create a coral reef.	
Circle of Life – Standard: Science 3 • Draw a “circle of life” diagram that shows relationships between plants and animals in a coral reef community. • Describe your drawing, explaining how both simple food chains and food webs can be traced back to plants.	
Land to Sea Survival Shuffle – Standards: Science 3 & 5 • Draw both land and sea habitats used by turtles, seabirds, and monk seals. Include the foods they eat and their predators. • Describe how the beach and ocean environments determine nesting and feeding behaviors. • Describe the specific environmental conditions these animals need to survive. Explain what people can do to help the animals survive.	
Gr. 5	
Circle of Life – Standard: Science 3 • Draw a “circle of life” diagram that shows relationships between plants and animals in a coral reef food web. • Describe your drawing by explaining how matter is cycled among producers, consumers, and decomposers.	
Land to Sea Survival Shuffle – Standard: Science 3 • Draw both land and sea habitats used by turtles, seabirds, and monk seals. Include the foods they eat and their predators. • Describe your drawing and explain the cycle of energy among producers, consumers, and decomposers.	

Culminating Activity

As you work on your journal, you will be working toward completing the culminating activity for this unit. Your challenge: Interview a Hawaiian kupuna to find out how Hawaiians understand the connection between themselves and all living things and the connection between life on land and life in the sea. Write a story to summarize what you learn from the kupuna and how it applies to what you have learned in this unit. Your story should include:

- Drawings showing the connection between life on land and life in the sea
- An explanation of the “circle of life” showing the relationships between plants and animals in a coral reef food web
- Descriptions that meet the standard benchmarks in the rubric on the following page

Unit 2 Culminating Activity Rubric - Gr. 4

DOE Benchmarks & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	\`Ano Mākaukau (Almost at Standard)	Mākaukau \`Ole (Below Standard)
Science 3: Life and Environmental Sciences: Interdependence Describe how an organism's behavior is determined by its environment. Points ___	Your story explains and gives examples of how the behavior of different animals is determined by their environments.	Your story describes how the behavior of different animals is determined by their environments.	Your story identifies a way that an animal's behavior is influenced by its environment.	Your story recognizes that an animal's behavior is influenced by its environment.
Science 5: Life and Environmental Sciences: Unity and Diversity Describe the roles of various organisms in the same environment. Points ___	Your writing analyzes how the roles of different animals affect the way they interact in the coral reef community.	Your writing describes the roles of different animals in the coral reef community.	Your writing identifies a few animals and their roles in the coral reef community.	In your story, you were able to recall, with assistance, very few animals and their roles in the coral reef community.
Science 5: Life and Environmental Sciences: Unity and Diversity Describe how different organisms need specific environmental conditions to survive. Points ___	Your story explains why different organisms need specific environmental conditions to survive.	Your story describes how different organisms need specific environmental conditions to survive.	Your story lists specific environmental conditions that organisms need to survive.	Your story recalls that organisms need specific environmental conditions to survive.

Unit 2 Culminating Activity Rubric - Gr. 5

DOE Benchmarks & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Science 3: Life and Environmental Sciences: Interdependence Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter. Points ___	Your story explains and gives examples of how specific relationships among producers, consumers, and decomposers in the coral reef ecosystem affect the cycling of matter.	Your story describes the interdependent relationships among producers, consumers, and decomposers in the coral reef ecosystem in terms of the cycling of matter.	Your story identifies a few relationships between producers, consumers, or decomposers in the coral reef ecosystem in terms of the cycling of matter.	In your story, you recall, with assistance, that matter cycles in the coral reef ecosystem among producers, consumers, and decomposers.
Science 3: Life and Environmental Sciences: Cycles of Matter and Energy Describe the cycle of energy among producers, consumers, and decomposers. Points ___	Your writing and/or drawings explain and give detailed examples of the cycle of energy among producers, consumers, and decomposers.	Your writing and/or drawings describe the cycle of energy among producers, consumers, and decomposers.	Your writing and/or drawing describe a part of the energy cycle with an example (e.g., describes one or two parts of a food chain).	Your writing and/or drawing recognizes an example of part of an energy cycle.
Nā Honua Mauli Ola #8 -12 Learners pursue opportunities to observe and listen to expert resources within the community. Points ___	Your story is an excellent summary of the Hawaiian view of the land to sea connection. Examples provided show application to what has been learned in the unit.	Your story is a good summary of the Hawaiian view of the land to sea connection. Examples provided help to show what has been learned.	Your summary of the Hawaiian view of the land to sea connection needs more examples to be clear.	Your story does not show evidence of learning about the Hawaiian view of the land to sea connection.

Reef Builders

Essential Question: What roles do corals play in the coral reef ecosystem?

Hawai`i DOE Content Standards

Science 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution – Unity and Diversity.

- Understand genetics and biological evolution and their impact on the unity and diversity of organisms.

Grade 4 Benchmark

4.5.2 Describe the roles of various organisms in the same environment.

Key Concepts

- Tiny animals called "polyps" construct corals. Most coral reefs are formed by many polyps living together in a colony.
- Corals are both producers and consumers. They use their stinger-lined tentacles to capture tiny animals (plankton) that drift by in the currents.
- Corals also obtain food through a unique relationship with single-celled algae that produce sugar through photosynthesis.

Activity at a Glance

Students make models of coral polyps and create the coral framework for a class coral community mural that they will complete in the "Circle of Life" lesson that follows.

Time

2 class periods

Assessment

Students:

- Complete a model of a coral polyp depicting the algae and coral.
- Write a journal entry to describe the roles of the algae (zooxanthellae) and the coral in the coral reef environment. Writing should include how coral polyps create a coral reef.

Rubric
Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Analyze how the roles of different organisms affect their interaction in the same environment.	Describe the roles of different organisms in the same environment.	Identify a few organisms and their roles in the same environment.	Recall, with assistance, very few organisms and their roles in the same environment.

Vocabulary

algae – simple plants that live in water
community – an assemblage of plants and animals living within a defined area
nutrients – any substance that promotes growth in living organisms
photosynthesis – the process of using energy from the sun to make starches and sugars from carbon dioxide and water
plankton – tiny floating or drifting organisms in the water
coral polyp – a tiny animal with a soft body and feeding tentacles that surround the mouth
producers – organisms that use energy from the sun to produce their own food
consumers – animals that get their energy by feeding on plants or other animals
zooxanthellae – microscopic, single-celled algae that live inside the tissues of corals and some other animals

Materials

- student journal and assessment pages (provided in Unit Overview)
- Navigating Change photo CD (provided)
- student reading (provided)
- modeling clay or play dough (two different colors)
- tape
- stapler
- scissors
- construction paper
- drawing pens
- colored markers
- dead coral specimens

Advance Preparation

Make a copy of the student reading for each student. Also make a copy of the student journal and assessment pages from the Unit Overview for each student. Gather some dead coral from the beach and bring it to class. Gather the modeling clay and craft materials listed above. Clear a wall space for students to begin working on a coral reef community mural.

Background Information

(Provided in student reading material.)

Teaching Suggestions

Introducing the Unit:

Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.

1. Divide the class into groups and give each group a sample of coral to examine. Ask students to give their coral a name and come up with adjectives that describe it. Ask students to describe what they think the coral is made of and how coral reefs are formed.

2. Record students' ideas about coral on the board. Show the image of the coral reef from the Navigating Change photo CD provided with the Teacher's Guide. Ask students to find the different species of coral that are pictured in the photograph.

3. Distribute the student reading and have students take turns reading it aloud. Revisit their ideas about coral and fill in new information on the board.

4. Give each student a small handful of modeling clay or play dough (in two colors). Ask students to create a model of a coral polyp using one color of clay to make a cup-shaped skeleton and the other to make the polyp with its tentacles.

5. Have students make small labels for their models and display them in the classroom. If desired, they could join the models together to make a model reef.

6. Show students the area set aside for the coral community wall mural. Distribute craft materials and have students create the reef from paper cut-outs. Ask each group of students to create a different type of coral to make up the reef. Explain that the mural will be completed with plants and animals in the activity that follows.

Extended Activity

Have students create a pop-up reef model of either the NWHI or the main Hawaiian Islands. Models for the pop-up reef can be found in the Unit 3 Appendix. Students can find additional information about reef organisms at:

- http://waquarium.otted.hawaii.edu
- http://www.coralreefnetwork.com/
- http://explorers.bishopmuseum.org/nwhi/
- http://www.hawaiireef.noaa.gov/about/welcome.html
- http://www.bishopmuseum.org/research/natsci/fish/fishimages.html

Resource Materials

Orr, Katherine. (1992).The Hawaiian Coral Reef Coloring Book. Owings Mills, MD: Stemmer House Publishers.

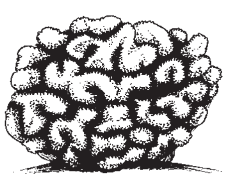
Maragos, J. & Gulko, D. (Eds.). (2002). Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim results emphasizing the 2000 surveys. Honolulu, HI: U.S. Fish and Wildlife Service and the Hawai'i Department of Land and Natural Resources. (See color images and information on pages 14-15.)

What are corals?

Scientists originally thought corals were plants because they didn't seem to move around. Today we know that tiny animals called "polyps" construct corals. Most polyps are no bigger than a grain of rice, and it takes many polyps living together in a colony to build coral reefs. Each polyp sits within a cup-like skeleton and is connected to its neighbor polyps by a layer of living tissue. The tiny coral polyp has a sac-like gut with a single opening (the mouth) surrounded by a ring of tentacles. The tentacles are imbedded with hundreds or thousands of tiny stinging cells used for defense and capturing prey.

As polyps grow, more polyps will form from their sides. More polyps will continue to bud in this way, leaving behind an empty skeleton. While this empty skeleton coral may look like rock, it is not, since rocks are not made by animals. When coral polyps reproduce, the offspring drift in currents until they settle to form new coral colonies.

Corals come in many different shapes and sizes. The three most common stony corals in the main Hawaiian Islands are lobe coral, cauliflower coral, and finger coral. Each type of coral is adapted to live in a different habitat. Lobe corals form most of our reefs. Cauliflower coral lives in shallow waters where it is adapted to withstand wave action. Finger coral is found in deeper waters where there is less wave action.



Cauliflower Coral

Table corals are found primarily at French Frigate Shoals where they thrive in warm, calm waters. This type of coral is not found in the main Hawaiian Islands. To learn more about these fascinating corals go to: http://www.hawaiianatolls.org/research/NOWRAMP2002/features/mystery_of_corals.php

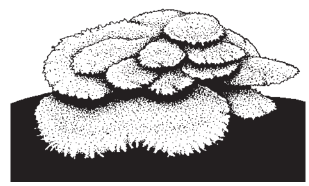
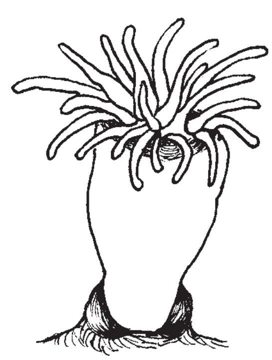


Table Coral

Some corals do not build reefs and are soft. Other corals live in very deep water, below where light from the sun can penetrate. These deep sea corals depend only on the plankton they catch with their stinging cells for food. The skeletons created by these deep-sea corals are very hard and some are harvested to make jewelry, like black and gold coral pendants.

What do corals eat?

Corals use their stinger-lined tentacles to capture tiny animals (plankton) that drift by in the currents. Plankton includes tiny crustaceans and mollusks that are barely visible without a microscope, as well as the tiny eggs and larvae of reef animals. Corals obtain most of their food through a unique relationship with single-celled algae called zooxanthellae. These algae live inside the coral tissues where they use the energy from sunlight to convert water and carbon dioxide into sugar. The algae use some of the sugar themselves, but much of it is available to the coral polyps.



Coral Polyp

Circle of Life

Essential Question: How are different reef organisms dependent on one another for survival?

Hawai`i DOE Content Standard

Science 3: Life and Environmental Sciences: Organisms and the Environment – Interdependence and Cycles of Matter and Energy

- Understand the unity, diversity, and interrelationships of organisms, including their relationship to cycles of matter and energy in the environment.

Grades 4 - 5 Benchmarks

4.3.1 Explain how simple food chains and food webs can be traced back to plants.

5.3.2 Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycles of matter.

Key Concepts

- Producers (algae, phytoplankton) provide oxygen and a source of food to marine animals.
- Marine animals (consumers including the herbivores, omnivores, and carnivores) provide carbon dioxide and nutrients to the plants (producers).
- The interdependence of producers, consumers, and decomposers creates a balanced ecosystem.

Activity at a Glance

Students work in teams to conduct research about the roles that different species play in a coral reef ecosystem. Students create a coral reef mural and play a team game using the research they have completed to help teach each other about the "circle of life."

Time

3 class periods

Assessment

Students:

- Complete a drawing of a "circle of life" diagram that shows relationships between plants and animals in a coral reef food chain and food web (Gr. 4) or food web (Gr. 5).
- Write a journal entry to describe the drawing, explaining how both simple food chains and food webs can be traced back to plants (Gr. 4).
- Write a journal entry to describe the interdependent relationships among producers, consumers, and decomposers in the coral reef ecosystem in terms of the cycling of matter (Gr. 5).

Rubric
Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Compare the characteristics of simple food chains with those of food webs.	Explain how both simple food chains and food webs can be traced back to plants.	Describe how simple food chains or food webs can be traced back to plants.	Recognize that simple food chains or food webs can be traced back to plants.

Advanced	Proficient	Partially Proficient	Novice
Explain and give examples of how specific relationships among producers, consumers, and decomposers in an ecosystem affect the cycling of matter.	Describe the interdependent relationships among producers, consumers, and decomposers in an ecosystem in terms of the cycling of matter.	Identify a few relationships between producers, consumers, or decomposers in an ecosystem in terms of the cycling of matter.	Recall, with assistance, that matter cycles in an ecosystem among producers, consumers, and decomposers.

Vocabulary

algae – simple plants that live in water
carnivores – animals that feed on other animals
community – an assemblage of plants and animals living within a defined area
consumers – animals that get their energy by feeding on plants or other animals
decomposers – organisms that help to break down plant and animal matter into nutrients that producers need to grow
ecosystem – the interacting system of living organisms and their environment
herbivores – animals that feed on plants
interdependence – the concept that everything in nature is connected to each other and cannot survive without the help of other plants, animals, and abiotic factors such as sun, soil, air, and water
nutrients – any substance that promotes growth in living organisms
omnivores – animals that feed on both plants and other animals
photosynthesis – the process of using energy from the sun to make starches and sugars from carbon dioxide and water
phytoplankton – single-celled or multi-cellular plants
producers – organisms that use energy from the sun to produce their own food

Materials

- coral community cards (provided)
- coral community drawing (provided)
- student research sheet (provided)
- Navigating Change slide show (provided on Navigating Change CD)
- tape
- stapler
- roll of string or yarn
- scissors
- construction paper
- drawing pens
- colored markers

Advance Preparation

Make one copy of each coral community card sheet. Copy the student research sheet for each student. Copy the coral community drawing onto a transparency.

Gr. 5 teachers should make a copy of the student journal and assessment pages from the Unit Overview for each student. Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.

Background Information

Coral reefs are complex communities of plants and animals. The colonies of corals that grow next to and on top of each other form the basis for this fascinating community, providing food, shelter, and diverse living spaces for many kinds of plants and animals. One way to understand the complex relationships among the plants and animals is to examine the roles that different species play in the coral reef community.

Corals are unique in that they play a dual role as producers and carnivores. The producers in the coral community also include the microscopic phytoplankton and the larger algae that use the energy from sunlight to convert water and carbon dioxide into sugar in the process of photosynthesis. The producers are the basis of the food chain, providing food for the herbivores, such as the turtles and colorful parrotfish that live on the reef. Carnivores, such as moray eels, monk seals, and sharks prey on the herbivores, which helps to keep their populations in balance. Darting among the corals are many beautifully colored fish that have adapted to feed on both plants and animals. These omnivores include the moorish idol, reef triggerfish, and the raccoon butterflyfish. Finally, the coral community would not be complete without the creatures that make up nature's clean-up crew. These decomposers include the crabs and lobsters that scavenge for food, feeding on decaying plants and animals.

Teaching Suggestions

1. Explain that students will be completing the coral community mural that was started in the previous activity. (If Gr. 5 students need a review of coral structure, refer to the Reef Builders lesson.) Ask students what they need to add to the coral to create this community. Show the Navigating Change slide show on the CD provided with the Teacher's Guide. Discuss students reactions to the images from the NWHI.

2. Project the coral community drawing using an overhead projector. Ask students to describe what they know about a coral reef ecosystem. Review what they know about the role of different members of the coral reef community (producers, herbivores, omnivores, carnivores, and decomposers). The dotted lines on the drawing show what each organism feeds on. Use this information to foster class discussion on the interdependence of the organisms that live on the coral reef.

3. Divide the class into six teams—the producers, herbivores, omnivores, decomposers, and two teams of carnivores. Give each team one page of coral reef community cards. Explain that these cards will be used in a game, but first each team needs to do some research to answer the questions on their cards. Distribute the student research sheet and review the tasks with students. (Note, if students are unable to find all of the answers in the course of their research, assist them with information provided on the teacher answer sheet.)

4. When teams complete their research, distribute craft materials for students to finish creating their coral community mural. Students may want to refer to the coral community drawing projected earlier as a guide.

5. When the mural is completed, have teams present what they have found in their research. Check their information against the teacher answer sheet provided, and have students make any necessary corrections. Ask other students to take notes. Explain that the information they record will help them to play a coral community game.

6. After each group's presentation, have students post their coral community cards on the mural they have created. Staple or tape the cards so that they can be flipped over to reveal the information on the back. Introduce the game using the game instructions provided at the end of this activity.

7. Ask students to complete the assessment activity by drawing a circle of life diagram. Have them add arrows to show the interdependence of different groups in the coral reef community. Ask students to write a paragraph n their journals that explains their drawings.

8. Have students share their drawings and discuss their ideas.

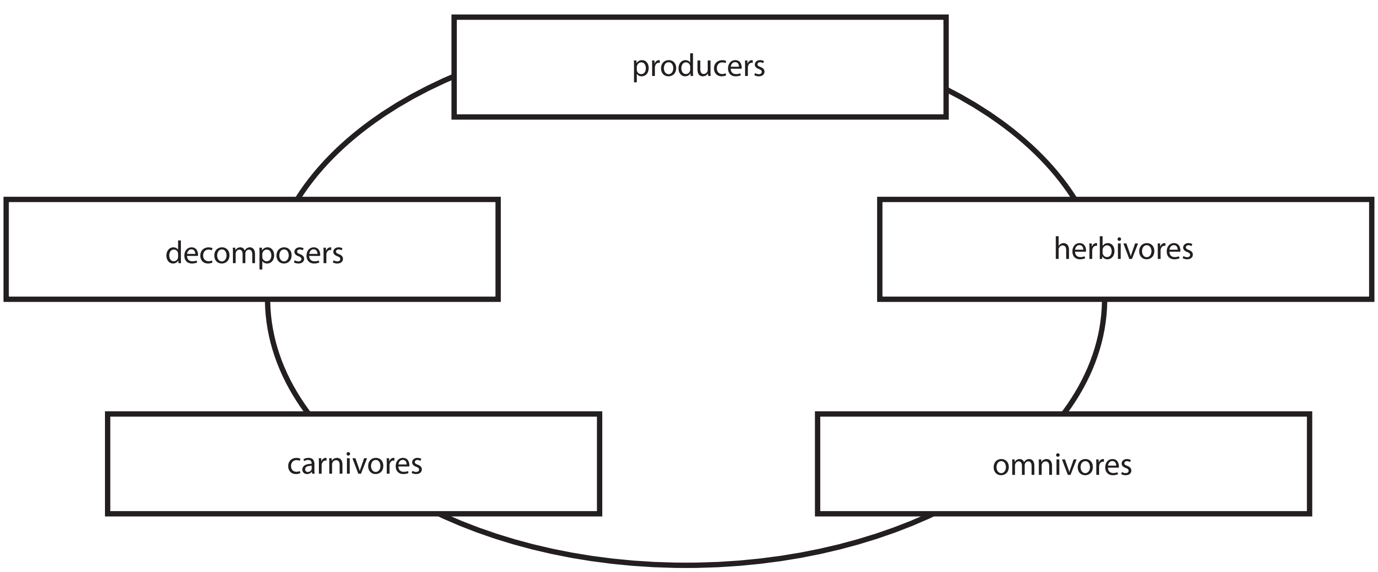
Discussion Questions

- What keeps the circle of life going?
- How is the circle of life like a web?
- What is the source of energy for the community?
- How would the coral reef community be affected if we eliminated one of the groups?
- What do producers provide for the community?
- What do consumers provide for producers?
- Which of the groups do you think has the highest populations of species? Why?
- What role do seabirds play in this community?

Extended Activities

Have students use their research to create an illustrated class book or field guide about the coral reef community to share with younger students. For additional information and images, see the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve's web site at: http://www.hawaiireef.noaa.gov/education/kids/.

Challenge students to use images from the CD provided with this guide to create their own multimedia presentations about the circle of life. Additional photographs of wildlife from the Midway Atoll National Wildlife Reuge are available from: http://midway.fws.gov/wildlife/default.htm.



Objective:

To discover relationships between plants and animals in the coral community

Game Set-up:

Teams of students gather around the coral reef mural they have created. Coral community cards are attached to the mural in a way that they can be removed or flipped over to reveal information. A helper from each team is chosen to represent the category researched. These helpers stand by the mural and assist with the game.

To Play:

- Have teams take turns selecting a category from the circle of life—producers, herbivores, omnivores, carnivores, or decomposers. They must select a category other than the one they researched!
- When a team selects a category to begin play, the helper from the team that researched that category points to the cards of the plants or animals in that category. (The two carnivore teams may alternate representing the carnivores.)
- The team playing selects one of the organisms on the cards. They have 60 seconds to check notes and identify a plant or animal on the mural that is connected to the organism, i.e., one that it eats or that eats it. For example, if the team chooses herbivores, the helper from the herbivore team points to the 4 herbivores on the mural. The team then picks one of the herbivores and identifies a plant that the herbivore eats or an animal that feeds on the herbivore.
- Once they identify a connection, the helper flips over the card of the herbivore and reveals if the answer is correct. The teacher has the final say on whether a connection is correct.*
- If the team is correct, one point is awarded. If the team is incorrect, other teams may raise hands to be called on to answer. The first team to answer correctly receives a point.
- After each turn, a check mark is made on the front of the card that was correctly answered and a string or yarn is attached to the mural connecting the two organisms.
- Continue playing until each team has had at least two turns.
- Once a team has chosen a plant or animal in a category, that card may not be chosen again by any teams.

Optional: Play a bonus round where each team selects one organism from a group other than the one they researched. Have teams call out their selections. Give everyone 60 seconds to come up with a fun fact or an adaptation the organism has developed to survive on the reef. Take turns letting each group relate its information and have the team helpers flip over the cards and check answers.

At the end of two or three rounds, add up points and declare a winner.

*Note that on the teacher answer sheet, some answers to "What does it eat?" are general, such as "small crabs" or "small fish" or "invertebrates." In these cases any fish, crab, or invertebrate will be considered a match in the game. Under the category of "Who are its predators?" some animals are listed as "herbivorous fish" or "carnivorous fish." In those cases, as long as students select a fish in the appropriate category their answers should be considered correct. For the purpose of understanding relationships among groups of organisms, having specific matches is not critical. "Correct" answers for the game are highlighted on the teacher answer sheet.

The coral reef community includes five groups of plants and animals. Find out what role each group plays in the coral community and describe this role below. The first one is completed for you as an example.

1. Producers – They provide food for plant-eating animals through photosynthesis. Photosynthesis is the process of using energy from the sun to make starches and sugar from carbon dioxide and water.

2. Herbivores

3. Omnivores

4. Carnivores

5. Decomposers/Scavengers

Challenge: Work together with your teammates to research the group of organisms on your coral community cards. Then work with other teams to complete a coral community class mural.

- Divide up the coral community cards among your team members and research the answers to the questions. Record your answers in the table on the following page. Then print answers neatly on the cards, which will be used in a game.
- Find out the color of the plant or animal and color the organisms on the cards.
- Create a coral community mural with other teams. Use construction paper to make cut-outs of the organisms on your cards. Work with other teams to make these cut-outs in proportion to each other so that the large carnivores are bigger than small herbivores. Place these cut-outs on the mural.
- Prepare to share what you have learned with other teams.

Circle of Life

Student Research Sheet

Conduct research to find the information on the back of your coral community cards. Record what you find in the table below.

Species	What does it eat?	Who are its predators?	How is it adapted to survive on the reef?	Fun Facts...

Check out these web sites:

Marine life – fishes, monk seals, sharks, seabirds, plants and algae:
- http://waquarium.otted.hawaii.edu/MLP/marine_life.html
- http://www.hawaiianatolls.org/keiki/index.php

Seabirds:
- http://midway.fws.gov/wildlife/birds.html
- http://www.botany.hawaii.edu/gradstud/eijzenga/ OIRC/oahu.htm

Spanish dancer sea slug:
- http://aquarium.ucsd.edu/learning/learning_res/voyager/nudibranch/

Sharks:
- http://aquarium.ucsd.edu/learning/learning_res/creature_features/sharks.cfm

Fishes:
- http://bishopmuseum.org/research/natsci/fish/fishimages.html

Corals:
- http://www.biosbcc.net/ocean/marinesci/04benthon/crani.htm
- http://coralreefnetwork.com/marlife/corals/porit.htm

Coral Community Cards — Teacher Answer Sheet

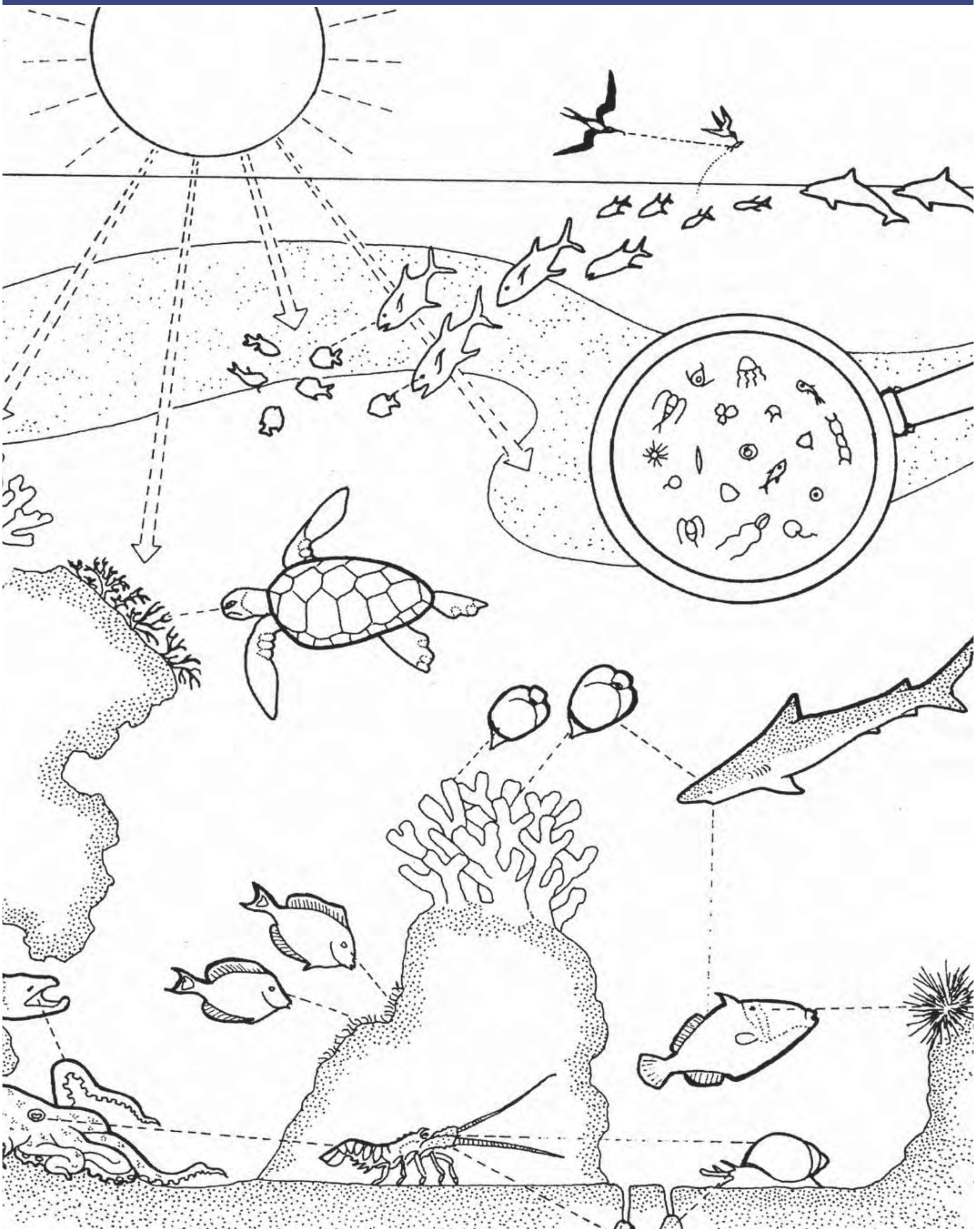
Organisms in bold are those that will be on the mural and will be answers to the game that students play.

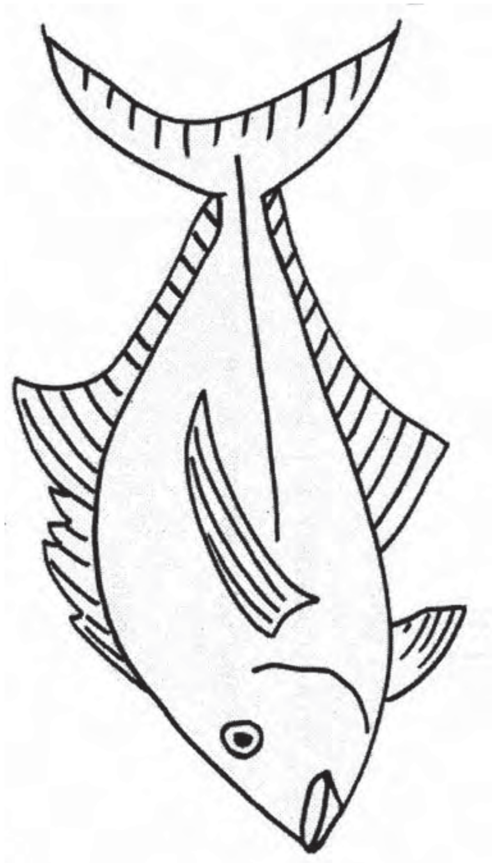
Species	What does it eat?	Who are its predators?	How is it adapted to survive on the reef?	Fun Facts...
Yellowfin goatfish – weke	Small crabs lobsters, fish, echinoderms, mollusks, worms	Humans	• Pushes its snout into sediments and expels sand via its gill cover	• In rare cases, can cause hallucinations when head is eaten
Spanish dancer	Sponges	Carnivorous fish	• Uses two long featherlike attachments that have chemical sensors to detect food • Uses camouflage; turns the color of what it eats • Stores poisons after eating poisonous sponges, then uses for protection	• Can swim for hours by undulating its body • When disturbed, flares out mantle edges, increasing size and display • Smells like freshly picked ginger
Red-footed booby	Small fish	Humans, sharks (eat juveniles)	• Has gland to wax feathers • Has pointed bill for catching fish	• They are dependent on large schools of `ahi for their survival. `Ahi force prey to the water surface where boobies catch them • Guano washing off islands creates a nutrient-rich food source for coral reef animals
Lobe coral – pōhaku puna	Zooplankton; nutrition through symbiotic algae	Humans, large parrotfish, butterflyfish, one type of blenny	• Have zooxanthellae (algae) living in their tissues, which produce sugars through photosynthesis	• Coral polyps reproduce and their offspring drift off to new areas and begin forming new coral colonies. They can also reproduce through fragmentation
Octopus – he`e	Mainly reef crustaceans (shrimp, lobster, crab), mollusks (primarily cowry snails), fishes	Humans, moray eels, sharks, monk seals, ulua, big fish,	• Changes skin color to match environment • Crawls with eight arms or uses "jet propulsion" to escape • Paralyzes prey with toxin in saliva • Squirts ink to hide during escape	• Probably the most intelligent of invertebrates • Able to change skin color to match the bottom as it swims
White-mouthed moray eel – puhi`oni`o	Reef fish, crustaceans (shrimp, lobster, crab), octopuses	Humans, ulua	• Hides in holes and crevices of the reef • Can move forward and backward • Can survive on only one meal for a long time	• Rarely aggressive unless threatened • Moray eels have back curved teeth; bites can be serious

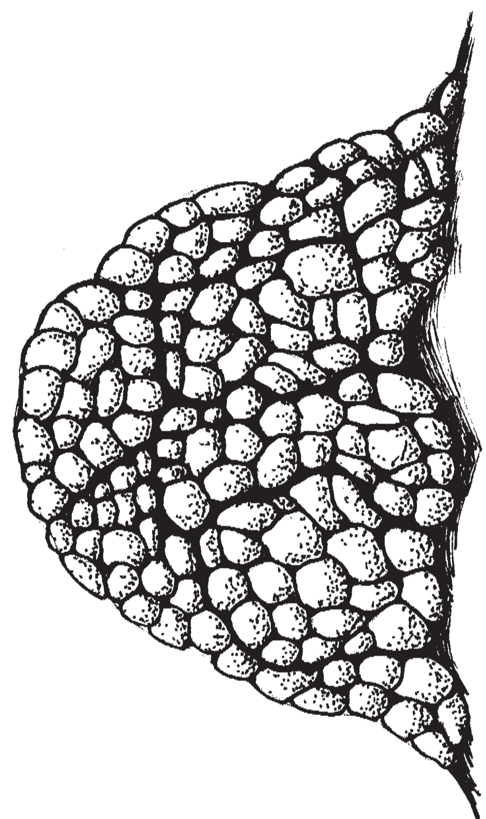
Hawaiian monk seal – `īlioholoikauaua	Reef fish, octopus, lobster, eel (except large morays)	Large tiger and Galapagos sharks	• Can dive as deep as 1,500 feet • Able to remain submerged for 15 to 30 minutes	• Capable of eating as much as 10% of their body weight in a day • Shed their skin (molt) each year • Most endangered marine mammal whose entire population is in U.S. waters
Blacktipped reef shark – manō	Reef fish, octopus, crustaceans (lobsters, crabs), dead animals	Humans, bigger sharks	• Has counter shading (camouflage) • Has excellent senses, including ability to detect electrical charge of buried prey • Hunts at night and dawn	• Teeth set in soft cartilaginous jaws pull out easily but are quickly replaced by constant growing of new rows of teeth • Skin is composed of needle-like teeth, or denticles, that point toward the tail
Sargassum seaweed – limu kala	Uses sunlight, carbon dioxide, and water to make sugars and starches	Humans, herbivorous fish	• Has a holdfast that keeps it in place • Can grow new plant from its holdfast • Has gas-filled floats among the blades that help keep it upright towards the sun	• In Hawaiian culture, limu kala is used to help loosen or remove wrong in settling disputes • Used in the purification ceremony after the death of a relative
Cauliflower coral – ko`a	Nutrients from symbiotic algae; zooplankton	Triggerfish, raccoon butterflyfish	• Uses stinger cells to paralyze its prey	• Early Hawaiians used the coral like sand paper. Also used in building of temples dedicated to fishing
Phytoplankton	Uses sunlight, carbon dioxide and water to make sugars and starches	Zooplankton, small fish, clams, oysters, whales	• Makes its own food using energy from the sun	• Billions of these cells provide most of the plant material consumed by animals in the ocean; gives water a green color
Ogo – limu manauea	Uses sunlight, carbon dioxide and water to make sugars and starches	Humans, herbivorous fish	• Has a holdfast that attaches to rocks and coral	• Has a mild flavor and crunchy texture; it is chopped and added to raw fish to make poke
Convict tang – manini	Algae	Humans, sharks, seals	• Has stripes that break up the body outline, which might confuse predators • Swims in schools • Has down-turned mouth with flexible comb-like teeth that are good for grazing on algae	• These algae feeders help to prevent fast-growing seaweeds from becoming dominant on the reef

Bullethead parrotfish – uhu	Algae	Humans, carnivorous fish	• Hides among the rocks and corals of the reef at night • Protects itself with a mucus cocoon while sleeping • Scrapes dead coral to feed on algae; pair of hard grinding plates in throat crushes coral into fine powder, eliminated as sand	• Estimated that a large parrotfish could produce as much as a ton of sand in a year • Terminal phase bullethead parrotfishes are males that started out as females
Rock-boring sea urchin – `ina	Algae	Triggerfish	• Lives in holes and depressions in rocks • Uses scraping jaws to deepen holes in rocks • Uses movable spines for protection	• Uses long sucker-tipped tube feet to move trapped food to mouth on its underside
Green sea turtle – honu	Algae; juveniles also feed on plankton, jellyfish, and fish eggs	Tiger sharks, humans	• When resting, can stay underwater for as long as 2.5 hours	• Migrates up to 800 miles from feeding areas near coast of MHI to nesting beaches in NWHI
Spiny lobster – ula	Reef invertebrates and dead animals	Humans, monk seals, sharks, large carnivorous fish	• Hides under ledges and in caves • Has powerful tail muscles that enable quick backward escape	• Active at night • Relies on spines covering its body rather than claws for protection
Hawaiian lobster – ula pāpapa	Mollusks (snails, oysters), invertebrates, dead animals	Humans, monk seals, sharks, large carnivorous fish	• Hides in crevices and caves of the reef	• Doesn't have any large claws
White crab – kūhonu	Dead or dying fish, small shrimp, worms	Eels, barracuda, large carnivorous fish	• Has strong spine on each side of carapace	• Hawaiian name, kūhonu, means "turtle back"
Thin-shelled rock crab – `a`ama	Dead or dying fish, small shrimp, worms	Eels, barracuda, large carnivorous fish	• It can dart and move quickly to avoid predators	• In times of trouble, it was said, "When the sea is rough, the `a`ama crabs climb up on the rocks"
Yellow-fin surgeonfish – pualu	Algae; young fish feed on zooplankton	Sharks, seals	• Uses two knifelike spines at base of tail to defend itself and catch prey	• Can alter its body color to nearly black with white ring around tail
Moorish idol – kihikihi	Sponges	Sharks, seals	• Extracts prey from crevices with elongated jaw • Has disruptive coloration that makes it hard to see where the fish starts and ends	• Hawaiian name means curves or zigzag

Reef triggerfish – humuhumu-nukunuku-apua`a	Snails, corals, shrimp, crabs, sea urchins	Sharks, seals	• Has eyes that are set high and move independently so that it can scan for food and predators at the same time • When threatened, dives into a crevice and wedges itself in by erecting large dorsal spines • Has fused teeth, which allow it to feed on hard-shelled animals	• Hawaiians made interesting use of triggerfish—they dried them to use as firewood, and used them as replacement for pigs in some religious ceremonies • In 1984, the reef triggerfish was selected as the official state fish of Hawai`i
Raccoon butterflyfish – kīkākapu	Tube worms, coral polyps, invertebrates, algae	Sharks, seals	• Has false eye spot near the tail that confuses predators.	• Juveniles recruit, or grow up, in tidepools • Common name comes from similar appearance to raccoons, with black bar across eyes



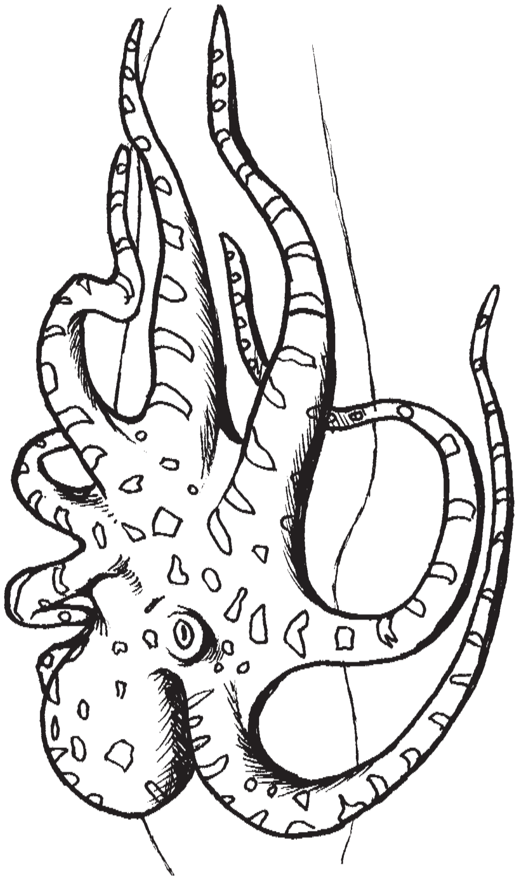


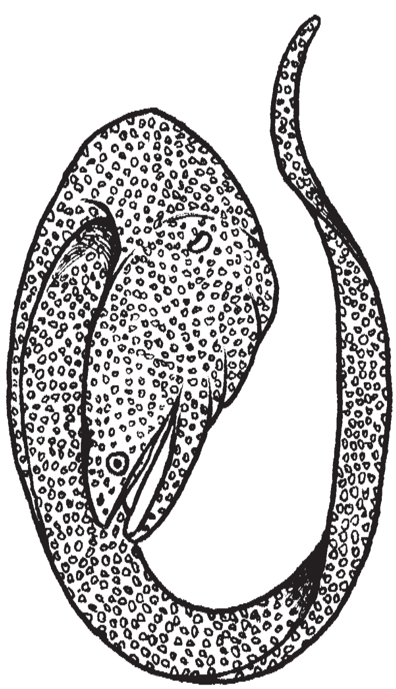


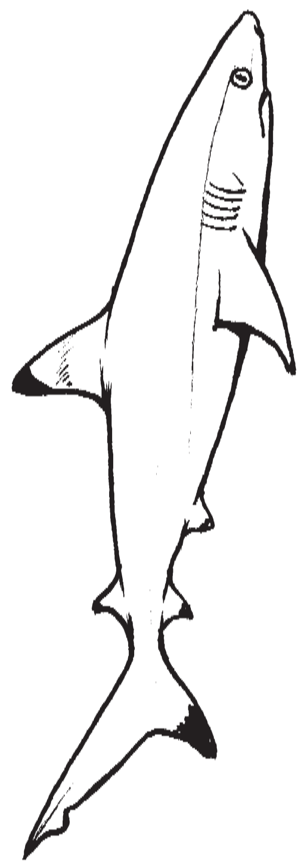
Coral Community Cards - Carnivores

Yellowfin Goatfish (Weke)	Spanish Dancer (Sea Slug)
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…
Red-Footed Booby	**Lobe Coral**
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…

Coral Community Cards - Carnivores

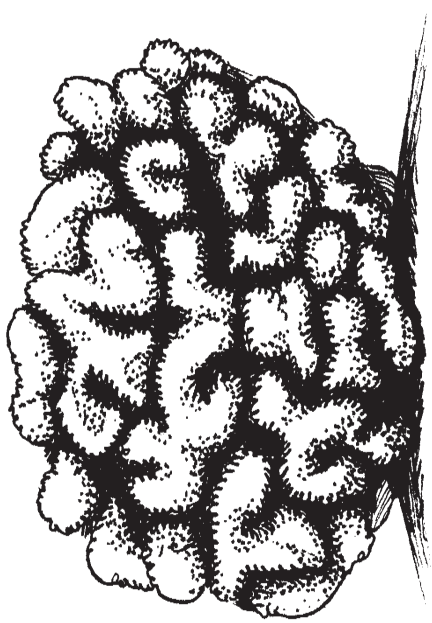


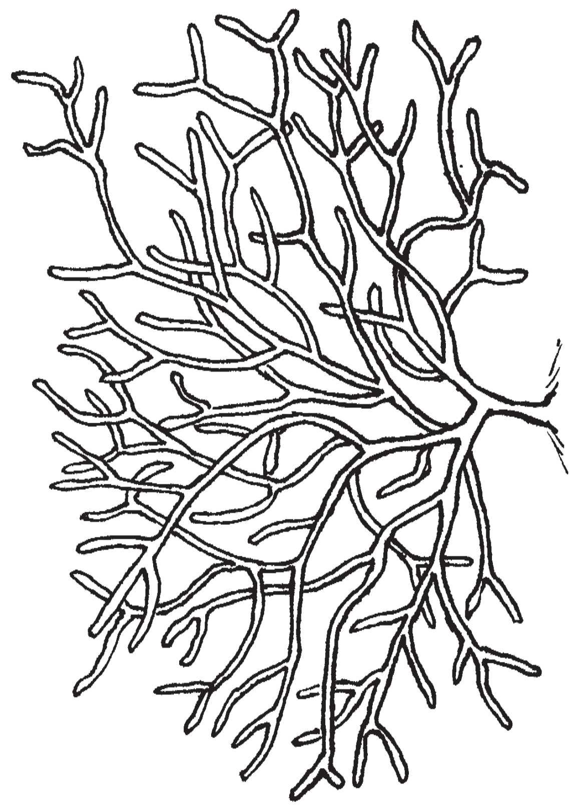




Coral Community Cards - Carnivores

Octopus (He`e)	Wide-Mouthed Moray Eel (Pūhi)
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…
Monk Seal (Īlioholoikauaua)	**Black-Tipped Reef Shark (Manō)**
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…

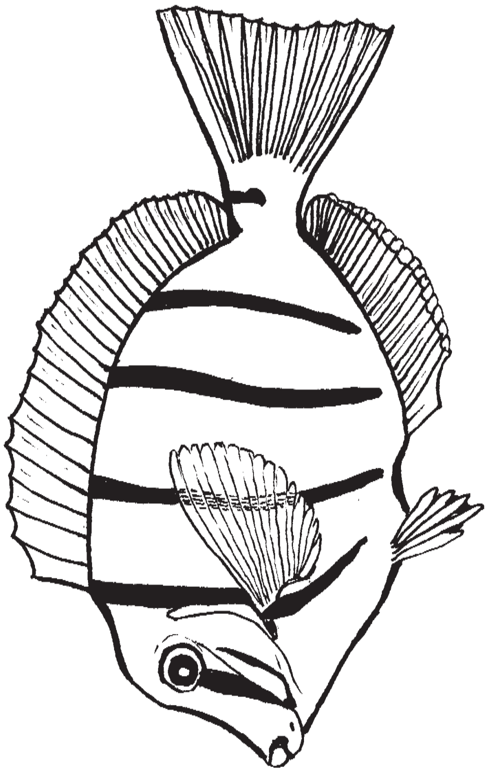


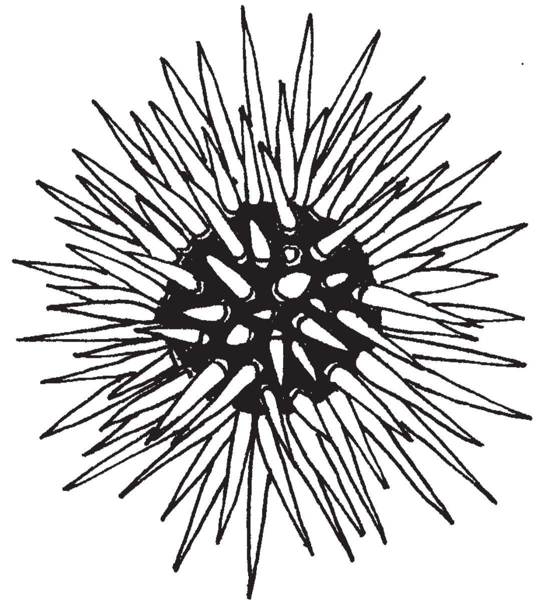


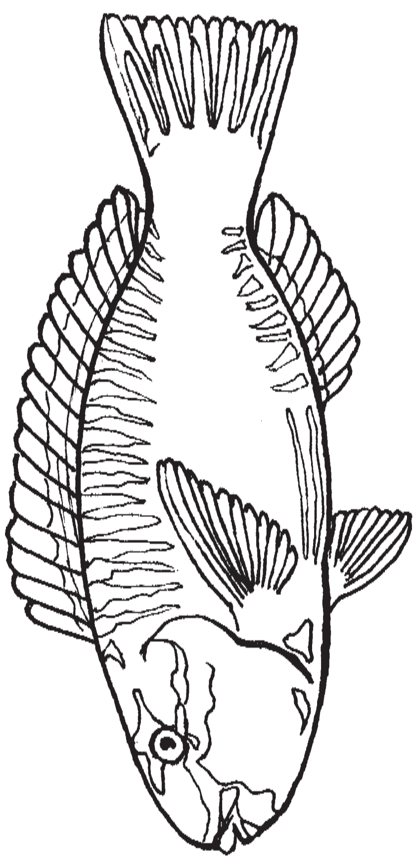
Coral Community Cards - Producers

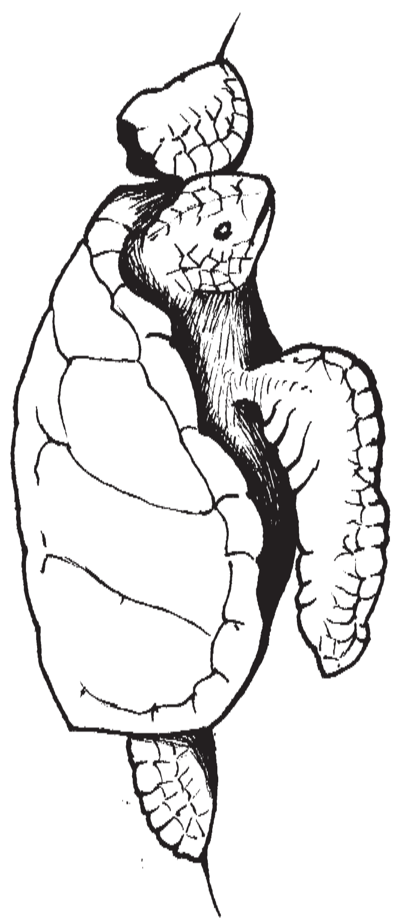
Sargassum Seaweed (Limu Kala)	Cauliflower Coral (Ko`a)
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…
Phytoplankton	**Ogo (Limu Manauea)**
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…

Coral Community Cards - Herbivores









Coral Community Cards - Herbivores

Convict Tang (Manini)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Bullethead Parrotfish (Uhu)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Rock-Boring Sea Urchin (`Ina)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Green Sea Turtle (Honu)

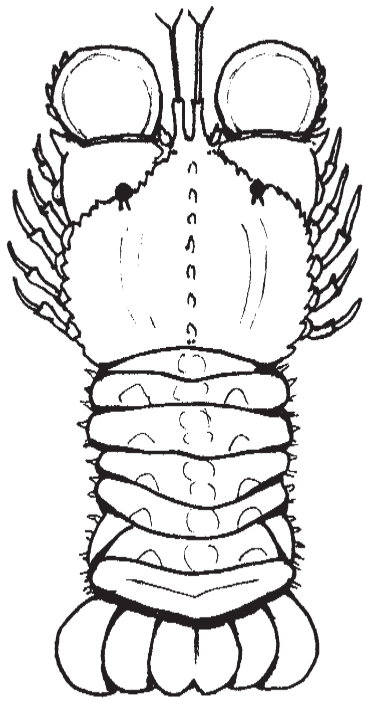
Discover:

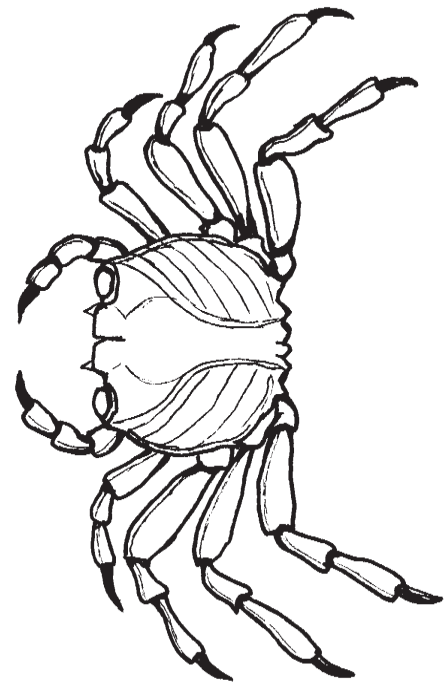
What does it eat?

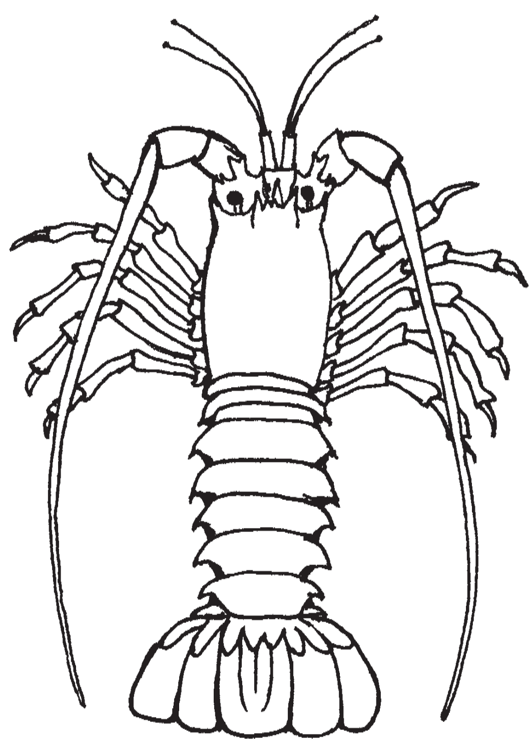
Who are its predators? (Find two.)

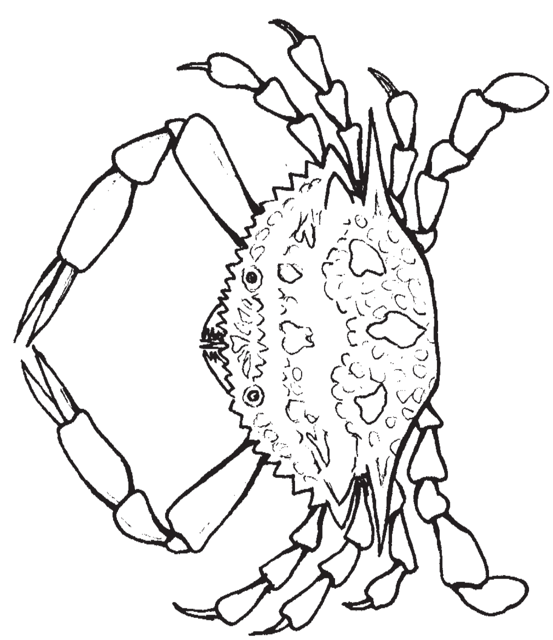
How is it adapted to survive on the reef?

A fun fact to share…





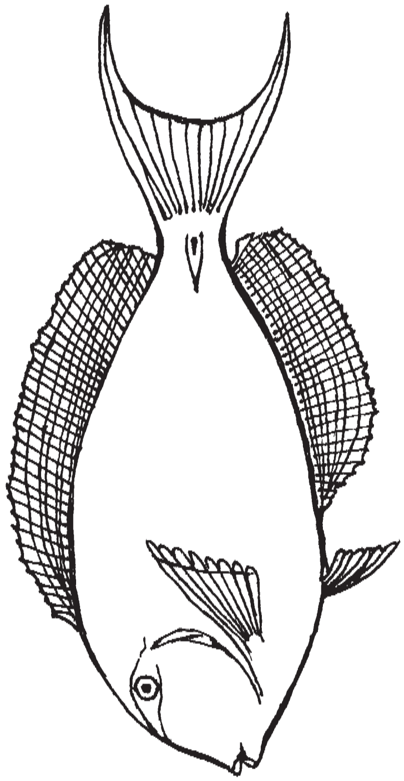




Coral Community Cards - Decomposers/Scavengers

Spiny Lobster (Ula)	Hawaiian Lobster (Ula pāpapa)
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…
White Crab (Kūhonu)	**Thin-Shelled Rock Crab (`A`ama)**
Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…	Discover: What does it eat? Who are its predators? (Find two.) How is it adapted to survive on the reef? A fun fact to share…

Coral Community Cards - Omnivores



Coral Community Cards - Omnivores

Yellow-fin Surgeonfish (Pualu)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Moorish Idol (Kihikihi)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Reef Triggerfish (Humuhumunukunukuapua`a)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Raccoon Butterflyfish (Kīkākapu)

Discover:

What does it eat?

Who are its predators? (Find two.)

How is it adapted to survive on the reef?

A fun fact to share…

Land to Sea Survival Shuffle

Essential Question: How are Hawaiian monk seals, seabirds, and green sea turtles dependent on both ocean and land habitats for their survival?

Hawai`i DOE Content Standards

Science 3: Life and Environmental Sciences: Organisms and the Environment - Interdependence

- Understand the unity, diversity, and interrelationships of organisms, including their relationships to cycles of matter and energy in the environment.

Science 5: Life and Environmental Sciences: Diversity, Genetics, and Evolution - Unity and Diversity

- Understand genetics and biological evolution and their impact on the unity and diversity of organisms.

Grades 4 - 5 Benchmarks

4.3.2 Describe how an organism's behavior is determined by its environment.

4.5.3 Describe how different organisms need specific environmental conditions to survive.

5.3.1 Describe the cycle of energy among producers, consumers, and decomposers.

Key Concepts

- Hawaiian monk seals, seabirds, and green sea turtles need both healthy land and sea habitats to survive; beaches are important resting places and the sea provides a habitat for feeding.
- Sharks, seals, seabirds, and sea turtles are part of a food chain in which each organism is dependent on other organisms for food.
- Human activities on beaches affect the survival of seals, turtles, and seabirds.

Activity at a Glance

Students play the role of monk seals, seabirds, and green sea turtles in an interactive outdoor game where they have to collect food cards without falling prey to a shark. They are challenged by marine debris and the loss of beach resting areas, which simulates human disturbances to land and sea habitats.

Time

2 - 3 class periods

Assessment

Students:

- Illustrate land and sea habitats used by turtles, seabirds, and monk seals and include their food sources and predators (Gr. 4 & 5).
- Write journal entries that describe how the animals' behaviors, such as nesting and feeding, are determined by the beach and ocean environment (Gr. 4).
- Describe the specific environmental conditions the animals need to survive, and what people can do to help (Gr. 4).
- Write journal entries to describe the cycle of energy among producers, consumers, and decomposers (Gr. 5).
- Diagram and describe the flow of energy among producers, consumers, and decomposers in the coral reef ecosystem (Gr. 5).

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Explain and give examples of how different organisms' behaviors are determined by their environments.	Describe how an organism's behavior is determined by its environment.	Identify a way that an organism's behavior is influenced by its environment.	Recognize that an organism's behavior is influenced by its environment.
Explain why different organisms need specific environmental conditions to survive.	Describe how different organisms need specific environmental conditions to survive.	List specific environmental conditions that organisms need to survive.	Recall that organisms need specific environmental conditions to survive.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Explain and give detailed examples of the cycle of energy among producers, consumers, and decomposers.	Describe the cycle of energy among producers, consumers, and decomposers.	Describe a part of the energy cycle with an example (e.g., describe one or two parts of a food chain).	Recognize an example of part of an energy cycle.

Vocabulary

predator – an animal that hunts and kills other animals for its food
prey – an animal hunted or caught for food
habitat – the place or environment where a plant or animal naturally lives and grows
endangered – plant or animal species in danger of going extinct
human disturbance – direct event created by people that results in harming plants or animals
extinction – the total disappearance of a species
invertebrate – an animal without a backbone
food chain – a sequence of organisms, each of which uses the next lower member of the sequence as a food source
ecosystem – the interacting system of living organisms and their environment
National Marine Sanctuary – a system of underwater parks, managed by NOAA'S Office of National Marine Sanctuaries, intended to protect and preserve biological, cultural, and historical resources
National Wildlife Refuge – a federal designation given to protected areas managed by the U.S. Fish and Wildlife Service for the primary purpose of providing necessary habitat for wildlife
Marine Protected Area – an area in which marine resources receive special protection
seabird – a bird that spends most of its life at sea

Materials

- monk seal, seabird, and turtle cards (provided)
- monk seal, seabird, and turtle food cards (provided)
- Navigating Change video segment - "Land to Sea Connection" (provided)
- shark headband template (provided)
- 12 X 12 cardboard, canvas or carpet squares (one for each student)
- scissors
- glue
- oak tag
- yarn or string
- rubber bands or elastic (for shark headband)

Advance Preparation

Make 5 copies of each food card page. Make 2 copies of each monk seal, seabird, and turtle card page (add additional copies if there are more than 25 students in the class). Use one color paper for the seal and its food, and different colors of paper for the turtle and seabirds and their respective foods. Glue the pages to cardstock, laminate them and cut out the cards. Punch holes in the seal, seabird, and turtle cards and attach yarn or string so students can wear the cards around their necks. Use the template provided to make a shark headband (make two if you have more than 30 students). Locate a grassy area suitable for running.

Background Information

Hawaiian monk seals, seabirds, and green sea turtles are highly dependent on both land and sea habitats. Hawaiian monk seals feed in the ocean and rest, safe from predators, on beaches. Seabirds feed and rest at sea and come to the land to breed and nest. Green sea turtles feed at sea and come to land to rest, reproduce, and lay their eggs. Both land and sea habitats are crucial to the survival of these three animals.

Hawaiian Monk Seals

Adult Hawaiian monk seals are more than 6.5 feet long and can weigh more than 400 lbs. When they are hunting on a reef, Hawaiian monk seals can remain submerged for 15 to 30 minutes, depending on how deep they dive and how active they are underwater. They can dive to a depth of more than 1,500 feet. They are solitary animals that are rarely found in groups. They are native to the Hawaiian archipelago, and their main breeding grounds are found in the NWHI, particularly around French Frigate Shoals. Waters around the islands are an important feeding area for Hawaiian monk seals. There, they feed on fishes, octopuses, eels, and lobsters that find shelter among colonies of deep-water corals. The seals also feed on flatfishes from sand fields. Hawaiian monk seals naturally spend about a third of their time resting and sleeping on isolated beaches. They are not "lazy," but conserve energy between their hunting and foraging trips. Large tiger sharks are their main natural predator, and the presence of sharks may be another possible reason for the seals to minimize their time in the water and maximize their time on the beach.

Seabirds

Seabirds have adaptations to the marine environment that makes them quite different from terrestrial birds. Like terrestrial birds, seabirds have hollow bones and specific bill adaptations to help them catch the food they eat. They add to the food chain by becoming prey, depositing guano on land and in the ocean, or when they decompose, adding nutrients to the cycle of life. Yet seabirds spend most of their lives at sea, coming to land only for breeding and nesting. They can eat, sleep, and rest at sea. They possess a special gland behind their eyes that desalinates saltwater so that they can obtain drinking water from the ocean. They have webbed feet, which allows them to take off and land skillfully on the water's surface. Many seabirds have feet placed farther back on their bodies, which allows them to propel themselves downward during a dive.

There are around 30 species of seabirds in Hawai`i, and many of them can only be found in the Northwestern Hawaiian Islands. Seabirds nest in colonies of a few hundred to several thousand or millions of birds. Most seabirds eat fish, squid, and floating materials such as fish eggs. The oldest known documented North American bird in the wild, a Laysan albatross, was found on Midway Atoll in 2002. The band numbers indicated it had been banded as an adult bird 51 years earlier! Currently we know seabirds live anywhere from 5 to 51 plus years and have a wingspan of a few inches up to 11 feet.

All seabirds are threatened in many ways by human activities. Although seabirds are rarely hunted by humans, they suffer because of pollution, marine debris, and disturbances to their breeding and nesting grounds as a result of human activities. Of particular threat are being hooked and drowning because they forage on bait food used by the commercial fishing industry; becoming entangled in disposed nets, gear, and plastic trash such as soda rings; and ingesting small, disposable cigarette lighters and other plastics. But probably the greatest threat to the successful breeding of these seabirds is the introduction of alien species such as rats, cats, dogs, and mongoose that kill the birds and eat their eggs. These non-native predators prevent seabirds from nesting in most areas of the main Hawaiian Islands, where they were once thought to be quite numerous.

Green Sea Turtles

Green sea turtles are air-breathing, cold-blooded reptiles. Adults can weigh up to 400 lbs. Their name comes from the color of the fat found inside their body rather than the color of their shell or skin. Ninety percent of Hawaiian green sea turtles rely on the sandy islets of the French Frigate Shoals as their breeding and nesting grounds. Sea turtles do not reach breeding age until 25 years of age.

Young turtles have a hard time and only one out of every thousand survive to adulthood. Young turtles that survive the crabs, seabirds, and ocean predators in their dash from nest to deeper waters disappear at sea for several years. No one knows where the young turtles go! They arrive in the main Hawaiian Islands around the age of seven. Juvenile green sea turtles eat sponges, seaweed, jellyfish, sea slugs, and violet snails. Adult turtles are almost exclusively herbivores. They feed on both sea grasses and algae, but occasionally will enthusiastically feed upon a large mass of invertebrates. They mostly feed on marine plants growing in shallow coastal waters. Hawaiian green sea turtles are found throughout the entire Hawaiian archipelago, a range of approximately 1,500 miles. Most Hawaiian green sea turtles seem to settle at a specific foraging ground and leave only to reproduce. It is believed that every nesting season, green sea turtles return to nest on the beach where they were born.

When they are active, Hawaiian green sea turtles must swim to the ocean surface to breathe every few minutes. When they are resting, they can remain underwater for as long as two and a half hours without breathing. Green sea turtles often rest in caves or under ledges in deep water. Hawaiian green sea turtles migrate up to 800 miles from their feeding areas near the coast of the main islands to nesting beaches in the NWHI. The males accompany the females in this migration and mate with them offshore from the nesting beaches.

One interesting behavior of the Hawaiian green sea turtle is its fondness for crawling ashore at isolated sites in order to bask in the sun. Hawaiian green sea turtles bask, but this behavior seems to be more prevalent in the Northwestern Hawaiian Islands. It is thought that they do this to warm up in the sun, rest, and perhaps to avoid tiger sharks. Two other threats to the survival of the green sea turtle are marine debris and a disease called Fibropapilloma. Marine debris, like nets, cigarette lighters, plastic bags, and ballpoint pens can clog their digestive system and cause turtles to starve to death. Fibropapilloma is a viral disease that causes large tumors to grow on the turtles, often to a size that obscures their vision or interferes with avoiding predators and with feeding.

Teaching Suggestions

1. Show the Navigating Change "Land to Sea Connection" video segment and discuss it.

   <u>Discussion Questions</u>
   - How are seabirds an important part of the circle of life? (They contribute guano to the water, which provides nutrients for plants. Plants are the base of the food chain for reef animals, providing food for a variety of fishes.)
   - Why do monk seals and green sea turtles need healthy beaches?
   - How are the animals' behaviors, such as nesting and feeding, determined by the beach and ocean environment?
   - What is the "land to sea connection"?

2. Review what students learned about interdependence in the Circle of Life activity. Display the cards provided with this activity and have students line up the cards to form food chains.

   Sample food chains:
   algae (limu) > green sea turtle (honu) > shark (manō)
   eel (puhi) > monk seal (`īlioholoikauaua) > shark (manō)
   octopus (he`e) > monk seal (`īlioholoikauaua) > shark (manō)

3. Introduce the Land to Sea Survival Shuffle game. Present the objective and assign a role to each student. Assign one or two students to be sharks (boy or girl) and have a third of the remaining students be turtles, a third be seabirds, and a third be monk seals.

4. Give each student a cardboard, canvas, or carpet square and bring the class to a grassy area suitable for running. If it's a windy day and canvas or cardboard is used, try wetting these squares to prevent them from blowing. Set the boundaries for the game and review game instructions provided at the end of this activity.

5. After the game, engage students in a discussion about the importance of healthy land and sea environments to the survival of monk seals, seabirds, and green sea turtles.

   <u>Discussion Questions</u>
   - How many seals, seabirds, and turtles were killed by the shark(s)?
   - Should we get rid of sharks? Why or why not? (Predators help the prey species by eliminating injured or sick animals and by controlling populations.)
   - What specific environmental conditions do the animals need to survive?
   - How does human activity on the beach increase the chances for seals/seabirds/turtles to fall prey to sharks? Is there a reason to limit human access to wildlife refuges? (Note that the Hawaiian Islands National Wildlife Refuge encompasses most of the islands in the NWHI.)

- What can we do to improve the chances for monk seal, seabirds, and sea turtle survival? Discuss such issues as eliminating or controlling human disturbance in wildlife refuges; protecting seals from human interference when they come ashore on main Hawaiian Islands; enforcing laws protecting these animals; expanding wildlife refuges; continuing research to understand monk seal, seabird, and sea turtle biology, diseases, and problems; eliminating marine debris; protecting pups, especially females, that have lost their mothers or been weaned early, and returning them to the wild.

6. Have students complete the culminating activity for the unit and allow time for them to share their stories with one another and/or with other classes.

Extended Activities

Have students write an imaginary story from the perspective of a Hawaiian monk seal, a seabird, or a green sea turtle. The story must describe what the animal eats, its predator, the habitat on land and sea needed for survival, and how the animal adapts to human changes to the land and sea environment.

Encourage students to research and report on sea turtles in the Islands. A web site with excellent information is: http://www.earthtrust.org/wlcurric/turtles.html.

Order a copy of the KidScience telecast "Land to Sea Connections" from the DOE Teleschool Office and view it with your class to reinforce concepts presented in this activity. See: http://www.teleschool.k12.hi.us/express/.

Borrow the video Midway Island of Life, from the U.S. Fish and Wildlife Service by calling 808.792.9532. It has spectacular wildlife footage particularly highlighting life cycles and food webs.

Objective:

To find enough food and return to the beach resting area (cardboard, canvas, or carpet square) before being eaten by a shark

Game Set-up:

- Students form a circle where they can just brush elbows with students next to them, place their squares on the ground in front of them, and sit down on the squares.
- Teacher stands in the center of the circle and introduces the game, while someone distributes the food cards randomly and widely around the outside of the circle.

Introduction

- Explain that the circle students have formed represents your island and that each turtle, sea bird, and monk seal has a safe place (carpet square) on this beach. This beach has a good reef offshore that prevents the shark from coming too close.
- The food cards spread around the "reef" are the foods that the turtles, seabirds, and monk seals need. The foods cards each animal needs match the color of the cards students are wearing.
- When given the signal to go, everyone must leave the beach and find a food card and then return to the beach (any carpet) without being eaten by a shark. Seals and turtles are solitary animals, so only one animal per square. Despite the fact that seabirds usually live in colonies, for the purpose of the game, there can only be one bird per square.
- Sharks may tag animals in the ocean but not on the beach. One touch is enough by the shark. Tagged animals must sit out and watch (designate an area).

To Play:

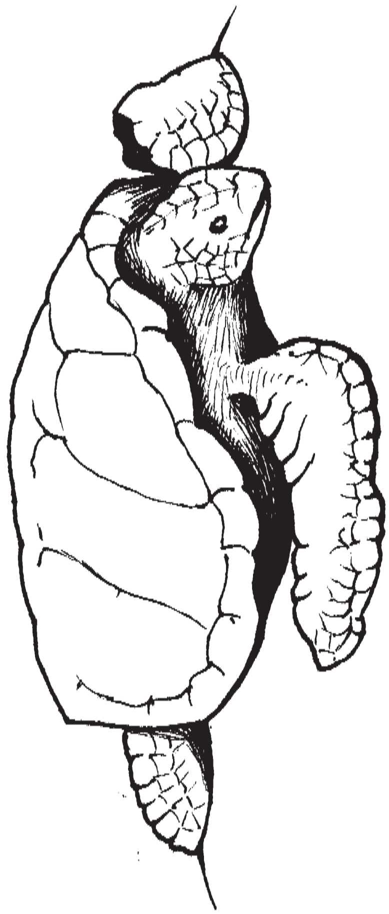
- Give the signal for round one.
- Continue playing until a whistle is blown or teacher calls time. At that time, the shark stops hunting and animals not tagged by the shark return to the beach.
- Look at the food cards and be sure that turtles, seabirds, and seals found their types of food. If they have the wrong type of food, they need to sit out the next round.
- Count how many seals, seabirds, and turtles were eliminated by the shark.
- Play a second round and repeat the steps above.

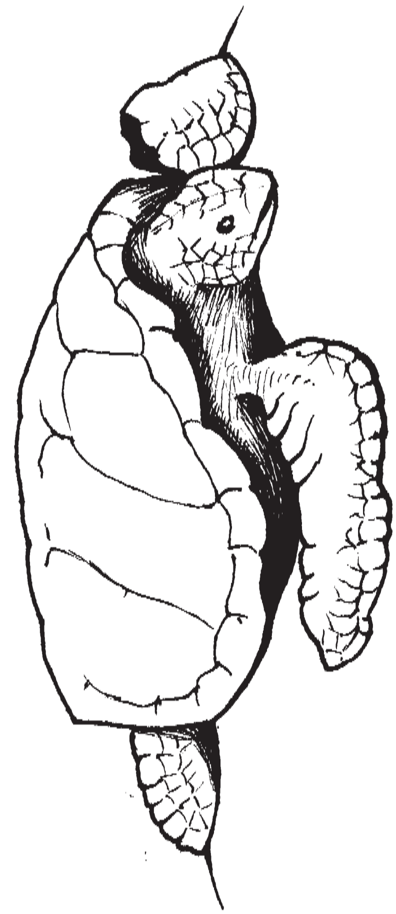
Play a third round but add another challenge—people wandering on the beach. This will eliminate some safe beach area so remove squares not in use and 4 or 5 more during the round. Explain that if animals can't find a square on the beach, they need to stay in the water with the shark.

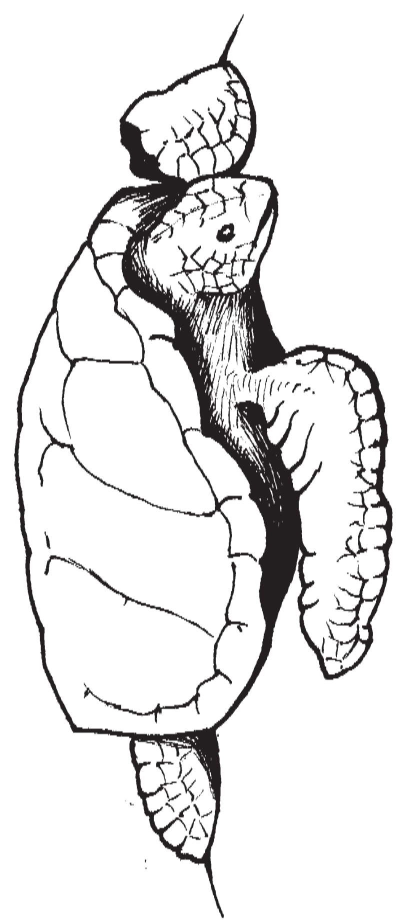
Play enough rounds that the monk seal, seabird, and turtle populations are seriously depleted or endangered.

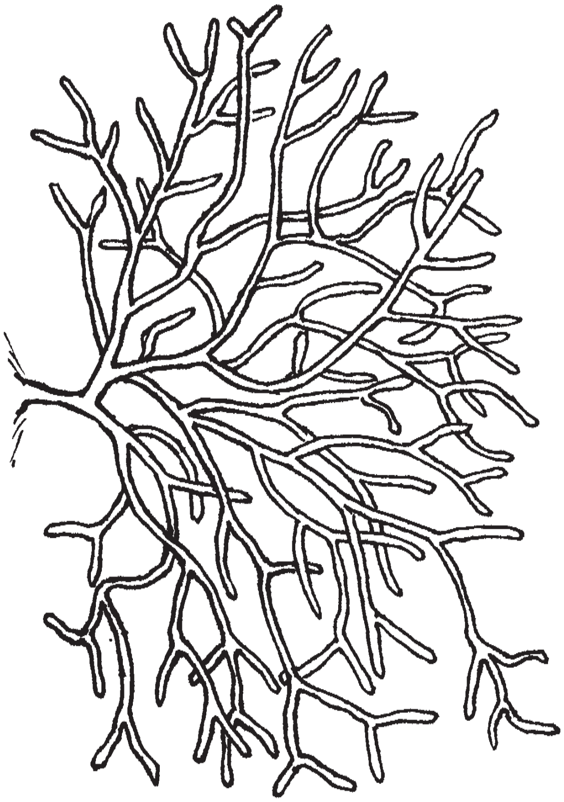
Source: Mahalo to the Waikīkī Aquarium Education Department, the University of Hawai`i. This activity is adapted from the Monk Seal Survival Shuffle.

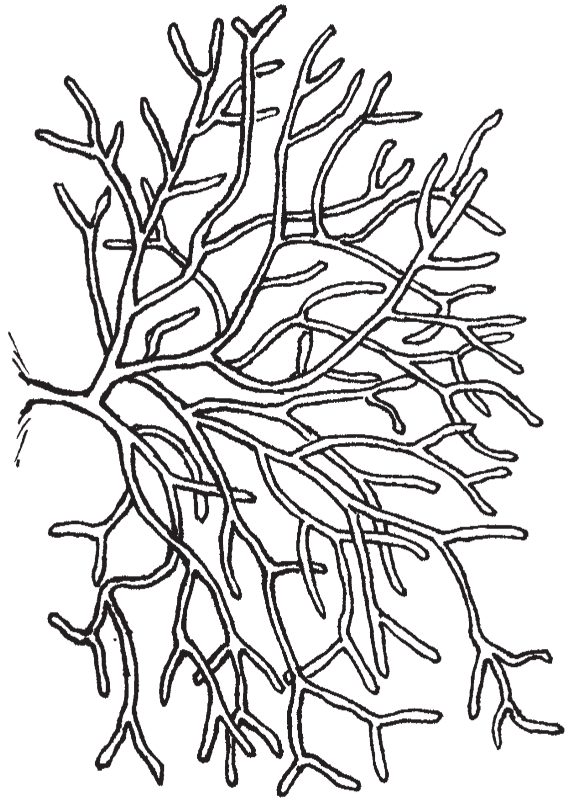
Sea Turtle Cards



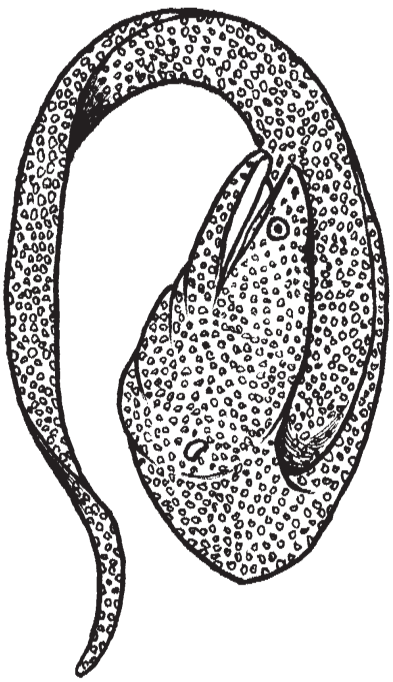


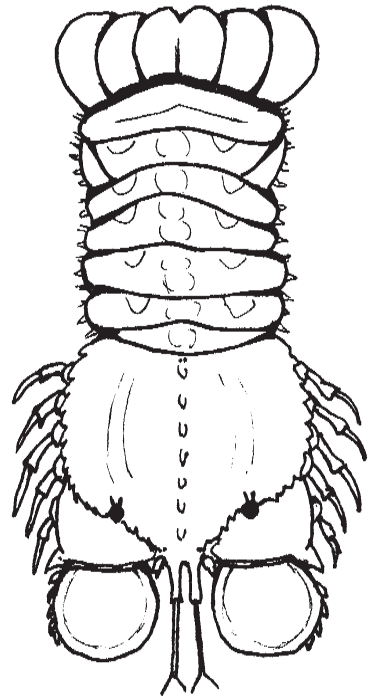


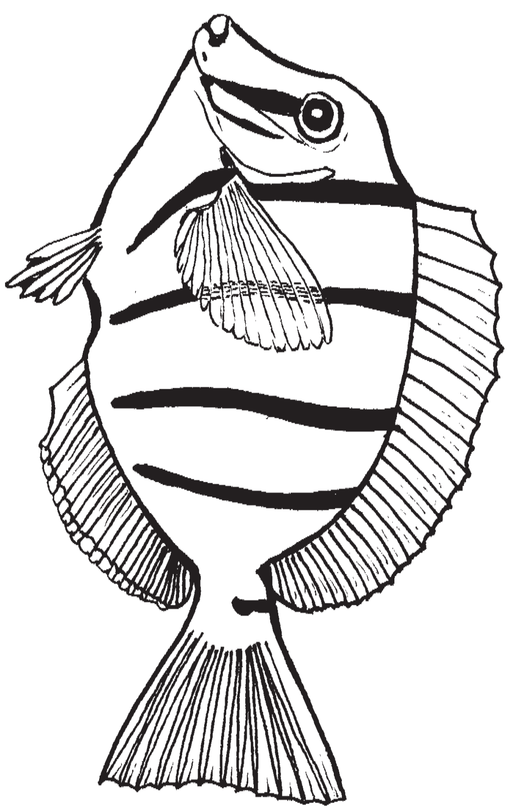


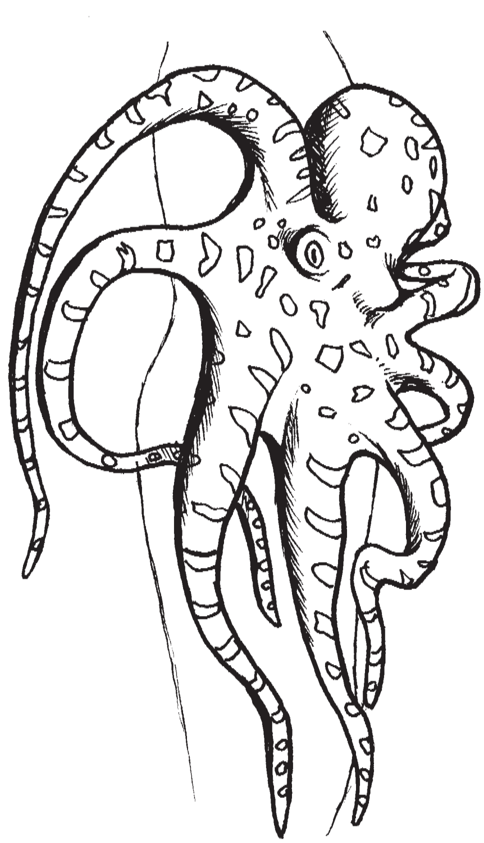


Monk Seal Cards



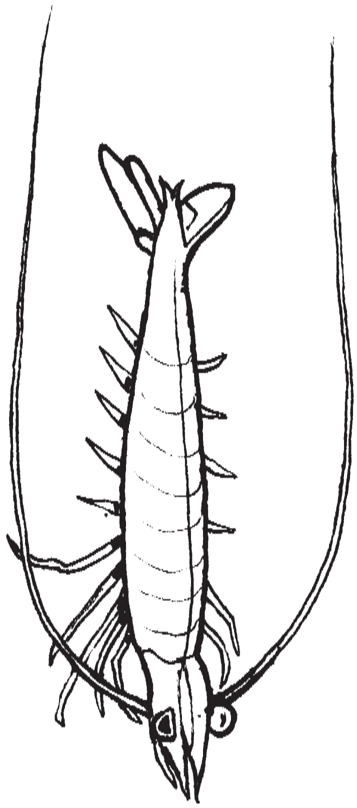


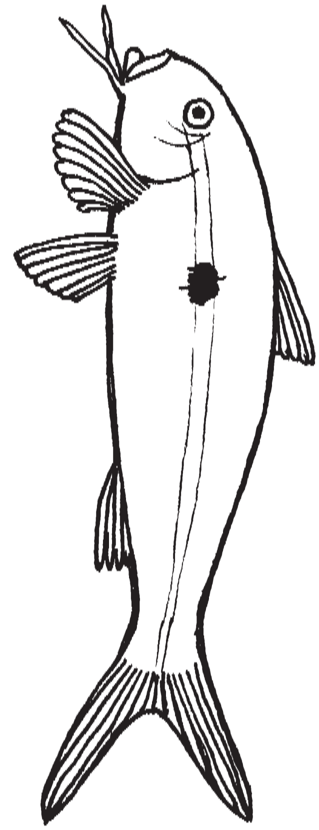


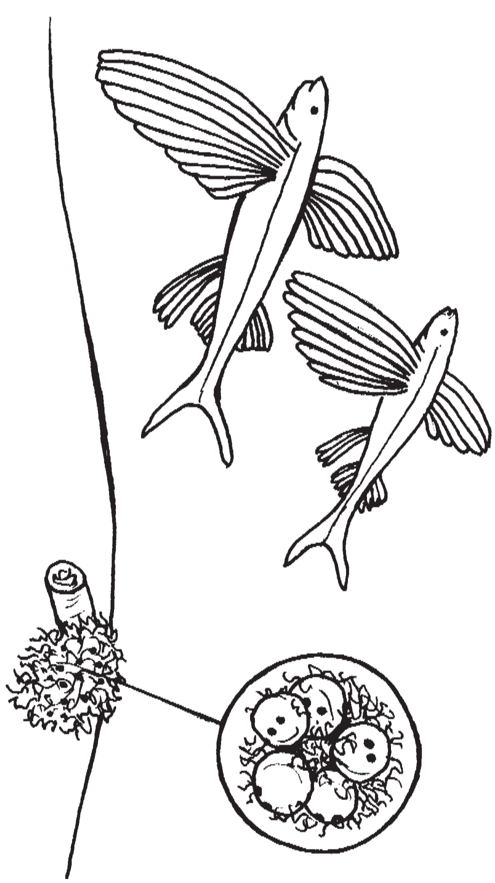


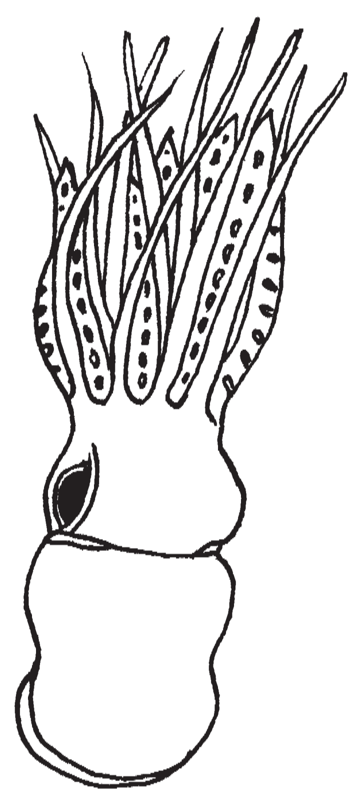
Monk Seal Food Cards

Seabird Cards





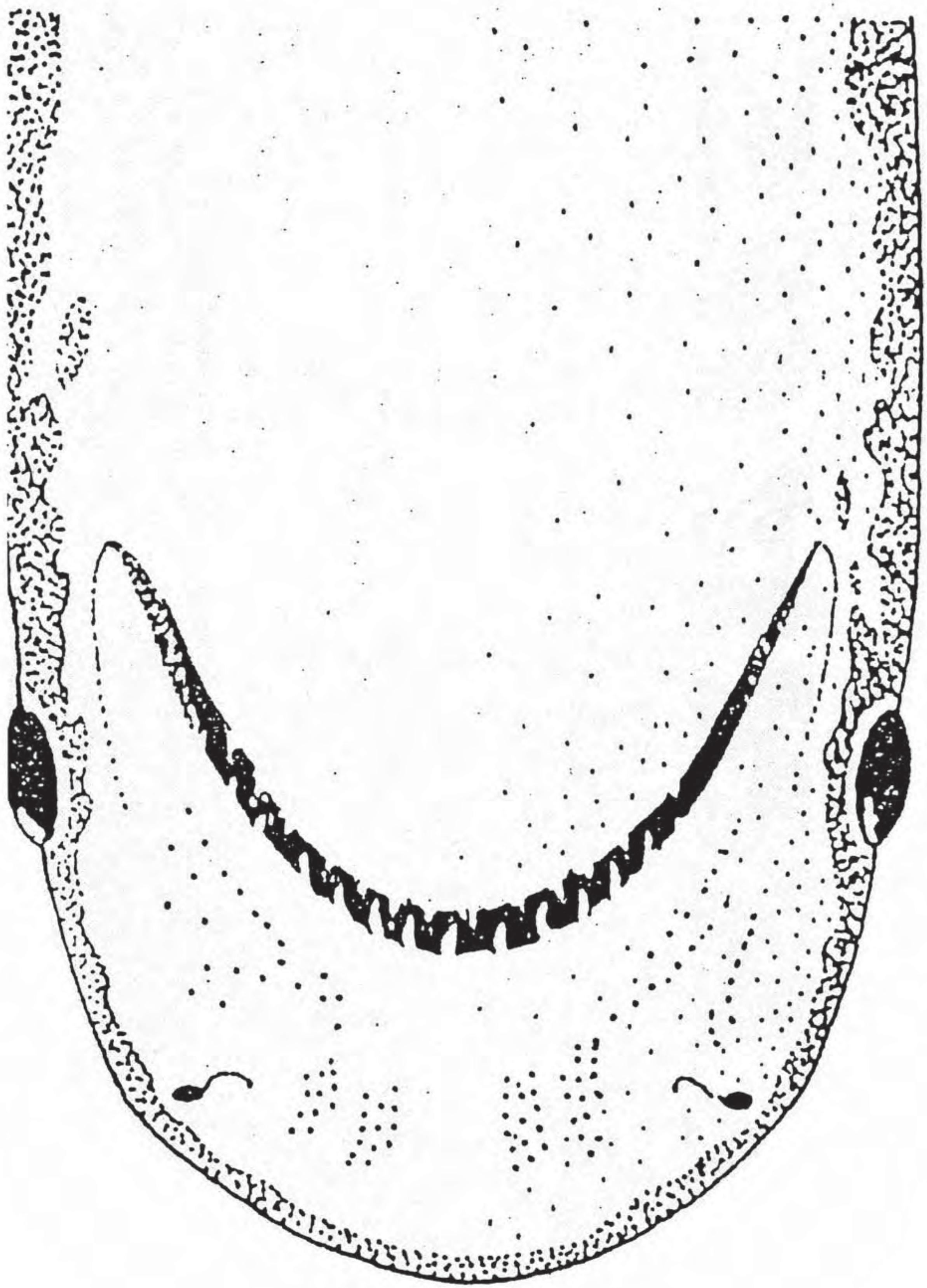




Shark Headband Template

Directions:

1. Cut out the headband and the shark head.
2. Fold the headband in the middle.
3. Tape the headband to the bottom of the shark head.
4. Staple rubber bands or elastic to each end to finish the headband.



Change Over Time

E uhi ana ka wā i hala i na mea i hala.

Passing time obscures the past.
— Mary Kawena Pukui, `Ōlelo No`eau #379

Change Over Time

When changes occur gradually over time it is difficult to conjure up the past and realize what has been lost. If we follow the path of the honu (Hawaiian green sea turtles) from the main Hawaiian Islands to French Frigate Shoals where most honu nest, we find a window to the past. In and around the clear waters where the honu feeds, the "kūpuna" islands reveal to us what a healthy coral reef and terrestrial ecosystem look like. By studying the ecosystem's complexity and abundance, and marveling at its beauty, we see what once was, and what we can work towards in restoring balance to our reefs around the main Hawaiian Islands. This unit is designed to help students peer through that window to the past and lay a foundation for positive change.

The Northwestern Hawaiian Islands and the reefs that surround them provide us with a chance to see what ecosystems throughout the main Hawaiian Islands may have looked like before the arrival of human beings more than 1,500 years ago. Very diverse and numerous unique species of endangered plants, land birds, seabirds, insects, corals, marine invertebrates, algae and sea grasses, fishes, sea turtles, and marine mammals all make the islands and reefs of the NWHI their homes.

"With coral reefs around the world in decline, it is extremely rare to be able to examine a coral reef ecosystem that is relatively free of human influence. Because of their relative isolation, the shallow reefs of the Northwestern Hawaiian Islands represent a large no-take zone, providing us with a unique opportunity to assess how `natural' coral reef ecosystems function in the absence of major human intervention."

— Alan Friedlander, fisheries ecologist with the Oceanic Institute and NOWRAMP expedition team member

In early 2000, an expedition to the Northwestern Hawaiian Islands was launched to map and assess the terrestrial environment and the shallow reefs of the islands for their biodiversity, status, and management needs. This expedition was a collaborative effort of 50 scientists participating in the Northwestern Hawaiian Islands Reef Assessment and Monitoring Program (NOWRAMP). The scientists studied emergent land habitats and participated in more than 1,000 dives to learn about the coral reefs of the NWHI. They collected hundreds of specimens, took photographs,

recorded video, and concluded that the islands were much more pristine and diverse than anticipated. Following are some general conclusions from the Executive Summary of the project:

- Jacks, sharks, and other top predators dominate fish populations, a situation not now encountered in any other large-scale coral reef ecosystem.
- Stony coral colonies are abundant, diverse, and often large (and likely very old in many areas), with total species variety exceeding that of the main Hawaiian Islands.
- One-fourth of the reef animals and plant species reported are unique to Hawai`i with many new species of sponges, algae, and coral discovered during the three expedition cruises.
- Marine debris continues to degrade reef habitat at many NOWRAMP sites, injuring and killing corals and other wildlife.
- Marine alien species do not appear to be a severe problem and are common only at Midway.
- Reef habitats are diverse, with some unique types not present in the main islands.
- Large pods of spinner dolphins are regular residents in several atoll lagoons, corroborating decades of similar observations by others.

Since 2000, two more NOWRAMP research expeditions were conducted to continue surveying this vast marine wilderness. Through the information gathered in these expeditions scientists are trying to determine a baseline for the region as a whole. This baseline will be used to evaluate the current health of the area and it will serve as a reference point to measure any changes in the region's ecosystems over time. The baseline will also help to prioritize any management or restoration efforts that the region may need. In addition to this survey, monitoring stations are being set up throughout the shallow waters of the region so that accurate measures of changes in specific areas can be recorded. The information collected at these sample sites will be used to determine the health of the shallow water areas across the region. It can also be very useful in determining the extent of coral bleaching events, or the accumulation of marine debris.

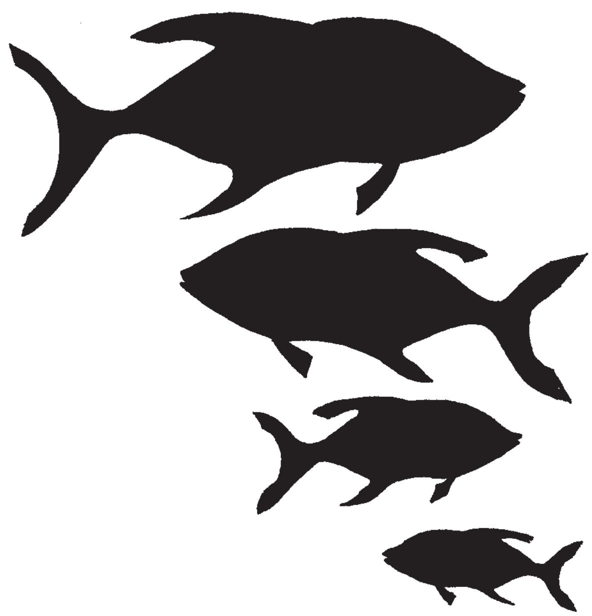
Change Over Time

Grades 4 - 5 Unit Overview

Hawai`i DOE Content Standards Nā Honua Mauli Ola	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Science 1: The Scientific Process: Scientific Investigation	How are the land and marine life of the "kūpuna" islands (NWHI) different from those of the main Hawaiian Islands (MHI)? Activity: Learning f rom the "Kūpuna" Islands	There are many differences between the "kūpuna" islands (NWHI) and the MHI. a) Most of the NWHI land is submerged so there is not much dry land. b) Thousands more seabirds nest in the NWHI than in the MHI. c) Almost all the green sea turtles in the Hawaiian archipelago nest in the NWHI and they are home to almost all Hawaiian monk seals. There are many differences between the ocean life and coral reefs of the NWHI and the MHI. d) There are more apex predators like sharks and ulua in the NWHI. e) Corals are found in greater health, variety, and number in the NWHI. f) Many species of corals, fish, and other sea animals that are abundant in the NWHI are rare in the MHI.	4.1.1 Describe a testable hypothesis and an experimental procedure. 5.1.2 Formulate and defend conclusions based on evidence.
Social Studies 7: Geography: World in Spatial Terms Environment and Society Science 2: The Scientific Process: Nature of Science Unifying Concepts and Themes GLO 5 Effective Communicator Nā Honua Mauli Ola #8 Pursue opportunities to observe and listen to expert resources within the community.	How has the coral reef in our community changed over time? Activity: Looking Back	• The coral reefs of the NWHI provide a baseline to see how reefs in the MHI have changed due to human activities. • Interviewing elder fishers and other resource people in the community is one way to learn about how the coral reefs have changed over time.	Social Studies 4.2.1 Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations. Science 5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world. GLO 5 Listens to, interprets, and uses information effectively.

Student Journal

Unit 3 – Change Over Time



E uhi ana ka wā i hala i na mea i hala.

Passing time obscures the past.

— Mary Kawena Pukui, `Ōlelo No`eau #379

Student's Name: ____________________

School: ____________________

Date started: ____________________

Date ended: ____________________

Student Assessment Overview

Unit Essential Questions

- How are the land and marine life of the “kūpuna” islands (NWHI) different from those of the main Hawaiian Islands (MHI)?
- How has the coral reef in our community changed over time?

How you will be graded for this unit:

Individual Journal

It is your responsibility (kuleana) to complete a journal for this unit. Following is a checklist of the pages you will need to include in your journal. Place this page in your journal and make a check next to each item when your complete it. You will be given more details during each lesson.

Journal Pages	✓ Completed
Gr. 4	
Learning from the “kūpuna” islands – Standard: Science 1 • Describe your testable hypothesis and the experimental procedure of the expedition. • Complete a Venn diagram that compares the land, fish, coral, other invertebrates, and limu of the NWHI and the MHI.	
Looking Back – Standard: Social Studies 7 • Summarize your conclusions about how human activities have affected coral reefs around the main Hawaiian Islands. • Develop a diagram, sketch, or graph to show how the coral reef in your community has changed over time.	
Gr. 5	
Learning from the “kūpuna” islands – Standard: Science 1 • Write and defend conclusions based on evidence gathered in the expedition. • Complete a Venn diagram that compares the land, fish, coral, other invertebrates, and limu of the NWHI and the MHI.	
Looking Back – Standard: Science 2 • Summarize your conclusions about how human activities have affected coral reefs around the main Hawaiian Islands. • Develop diagrams, sketches, or graphs as models to represent how the coral reef in your community has changed over time.	

Culminating Activity – Group Project

As you work on your journal, you will be working toward completing the culminating activity for this unit. Your challenge: Work in teams to present what you have learned about your coral reef to other classes in your school. You may use stories, songs, computer images, posters, photographs, models, or other methods. Your presentations should include the following:

- Evidence that the reef has changed over time, including conclusions about how the reef compares to reefs in the NWHI
- Conclusions about how human activities such as new fishing technology, overfishing, pollution, or development have affected the reef
- Diagrams or sketches to summarize changes to the reef
- What you have learned from kūpuna or others about how the reef has changed
- What people can do to mālama (care for) the reef

Use the rubric on the following page to guide you as you develop your presentation.

Unit 3 Culminating Activity Rubric - Gr. 4

Team Names____

DOE Benchmarks, GLOs, & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Social Studies 7: Geography Environment and Society Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations. Points___	Your presentation evaluated the ways that people have changed the environment and affected the coral reef. Your conclusions were relevant and insightful. Excellent use of diagrams or sketches to share information.	Your presentation analyzed the ways that people have changed the environment and affected the coral reef. Good use of diagrams or sketches to share information and relevant conclusions.	Your presentation described the ways that people have changed the environment and affected the coral reef. Your use of diagrams or sketches needed more work to share relevant conclusions.	Your presentation recognized that people have changed the environment and affected the coral reef. You need to use diagrams or sketches to share relevant conclusions.
GLO 5: Effective Communicator Communicates effectively and clearly through speaking, using appropriate forms, conventions, and styles to convey ideas and information for a variety of audiences and purposes. Points ___	The organization of your presentation was excellent. You understood the purpose and clearly presented information to your audience.	Your presentation was well organized. You understood the purpose and presented information so that the audience could understand it.	Your presentation was somewhat organized, but there is room for improvement. See notes on the other side of this page.	Your presentation was difficult to understand because it was not organized. See notes on the other side of this page.
Nā Honua Mauli Ola #2 - 5 Learners gather oral and written information from the local community and provide appropriate interpretation of its cultural meaning and significance. GLO 5: Effective Communicator Listens to, interprets, and uses information effectively. Points ___	Your interpretation of how the reef has changed showed excellent understanding of the oral and written information you gathered and the cultural significance of the changes to the reef.	Your interpretation of how the reef has changed showed good understanding of the oral and written information you gathered and the cultural significance of the changes to the reef.	Your interpretation of how the reef has changed showed you understand some of the oral and written information you gathered.	Your presentation did not interpret information that was, or should have been, gathered from the community.

Unit 3 Culminating Activity Rubric - Gr. 5

Team Names____

DOE Benchmarks, GLOs, & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Science 2: The Scientific Process: Unifying Concepts and Themes Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world. Points ___	Your presentation made excellent use of diagrams or sketches to share information about how the reef has changed over time and how it compares to reefs in the NWHI.	Your presentation made good use of diagrams or sketches to share information about how the reef has changed over time and how it compares to reefs in the NWHI.	Your presentation used diagrams or sketches, with assistance, to share information about how the reef has changed over time and how it compares to reefs in the NWHI.	Your presentation recognized that the coral had changed. You need to use diagrams or sketches to share information you have gathered.
GLO 5: Effective Communicator Communicates effectively and clearly through speaking, using appropriate forms, conventions, and styles to convey ideas and information for a variety of audiences and purposes Points ___	The organization of your presentation was excellent. You understood the purpose and clearly presented information to your audience.	Your presentation was well organized. You understood the purpose and presented information so that the audience could understand it.	Your presentation was somewhat organized, but there is room for improvement. See notes on the other side of this page.	Your presentation was difficult to understand because it was not organized. See notes on the other side of this page.
Nā Honua Mauli Ola #2 - 5 Learners gather oral and written information from the local community and provide appropriate interpretation of its cultural meaning and significance. GLO 5: Effective Communicator Listens to, interprets, and uses information effectively. Points ___	Your interpretation of how the reef has changed shows excellent understanding of the oral and written information you gathered and the cultural significance of the changes to the reef.	Your interpretation of how the reef has changed shows good understanding of the oral and written information you gathered and the cultural significance of the changes to the reef.	Your interpretation of how the reef has changed shows you understand some of the oral and written information you gathered.	Your presentation did not interpret information that was, or should have been, gathered from the community.

Learning from the “Kūpuna” Islands

Essential Question: How is the land and marine life of the “kūpuna” islands (NWHI) different from those of the main Hawaiian Islands (MHI)?

Hawai`i DOE Content Standard

Science 1: The Scientific Process: Scientific Investigation

- Discover, invent, and investigate using the skills necessary to engage in the scientific process.

Grades 4 - 5 Benchmarks

4.1.1 Describe a testable hypothesis and an experimental procedure.

5.1.2 Formulate and defend conclusions based on evidence.

Key Concepts

- There are many differences between the “kūpuna” islands (NWHI) and the MHI.
  a) Most of the NWHI land is submerged so there is not much dry land.
  b) Thousands more seabirds nest in the NWHI than in the MHI.
  c) Almost all the green sea turtles in the Hawaiian archipelago nest in the NWHI and they are home to almost all Hawaiian monk seals.
- There are many differences between the ocean life and coral reefs of the NWHI and the MHI.
  a) There are more apex predators, like sharks and ulua in the NWHI.
  b) Corals are found in greater health, variety, and number in the NWHI.
  c) Many species of corals, fish, and other sea animals that are abundant in the NWHI are rare in the MHI.

Activity at a Glance

Students develop a hypothesis about how plants or animals in the NWHI are different from those in the MHI. They take an imaginary expedition to study the plants and animals of the NWHI to discover what we can learn from these elder, “kūpuna” islands. Five teams of students become the class specialists studying one group of organisms on the expedition. The teams then do a jigsaw activity to form new groups with a specialist from each group sharing what has been learned.

Time

2 - 3 class periods

Assessment

Students:

- Describe their testable hypothesis and the experimental procedure of the expedition (Gr. 4).
- Teach other students about their hypotheses and the results of the expedition (Gr. 4).
- Formulate and defend conclusions based on evidence gathered in the expedition and teach other students about the conclusions (Gr. 5).
- Complete a Venn diagram that compares the land, fish, coral, other invertebrates, and limu of the NWHI and the MHI (Gr. 4 & 5).

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Create a testable hypothesis and an experimental procedure to test it.	Describe a testable hypothesis and an experimental procedure.	Identify, with assistance, a testable hypothesis and an experimental procedure.	Recognize, with assistance, a testable hypothesis or an experimental procedure.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Formulate and defend conclusions that are supported by detailed evidence and make connections to the real world.	Formulate and defend conclusions that are supported by evidence.	Make conclusions that are partially supported by evidence.	Make conclusions without evidence.

Vocabulary

acre – an area representing 4,840 square yards; there are 640 acres in one square mile
apex predators – animals at the top of the food chain, such as sharks
biodiversity – the abundance of native species in an area
biomass – total weight of living things in a defined area
emergent – above the surface of the water
endemic – unique to an area
invertebrates – animals without backbones
limpet – mollusk with a conical shell that clings to rocks and corals; `opihi
submerged – beneath the surface of the water

Materials

- student journal and assessment pages (provided in Unit Overview)
- student expedition sheets (provided)
- student summary sheet (provided)
- Venn diagram (provided)
- Navigating Change video segment "Change Over Time" (provided)
- Navigating Change photo CD (provided)

Advance Preparation

Make five photocopies of the student expedition sheets. (Make additional copies if needed, so that there is one copy of a team expedition sheet for each student in the five teams.) Make one copy of the Venn diagram and summary sheet for each student. Burn a copy of the Navigating Change photo CD for each of the five student expedition groups (or make copies of some of the color images to give to each group). Also make a copy of the student journal and assessment pages from the Unit Overview for each student.

Background Information

There are many differences between the NWHI and the MHI. Differences can be demonstrated by comparing the land, the corals, and the ocean fauna of the two island groups. One key difference is that despite the fact that the atolls and coral reefs of the northwestern part of the archipelago are called islands, they are not islands in the typical meaning of the word. In fact, most of their structure is submerged. Laysan Island is the largest natural dry land (Midway Atoll's Sand Island is larger, but it was enlarged by humans). Laysan Island's 1,015 land acres represent less than 2 square miles of land. In comparison, the smallest of the MHI is 166,425 land acres in size or 260 square miles.

Despite the fact that the NWHI have small land areas above sea level, these small areas are the homes of millions of birds, of 90% of nesting Hawaiian green sea turtles, and almost all of the endangered Hawaiian monk seals. The biomass of marine life (total weight of living things in a defined area) in the NWHI is three times that of the MHI. The coral reefs of the NWHI have many more apex predators, such as sharks and ulua, than the MHI. The presence of these animals in large numbers is generally indicative of a healthy ecosystem since there has to be sufficient numbers of species to support them. In contrast, the coral reefs of the MHI are mostly composed of small size, low-level carnivores and herbivores. The near absence of apex predators is attributed mostly to overfishing.

Even though the fish biomass is much greater in the NWHI than in the MHI, there are actually fewer species in the NWHI. Scientists believe this can be partially explained by the colder water temperatures in the NWHI.

Teaching Suggestions

Introducing the Unit:

Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.

1. Introduce the new vocabulary words and show the Navigating Change video segment "Change Over Time" to the class. Discuss students' reactions to the video.

Discussion Questions:

- What is one thing the "kūpuna" islands (NWHI) have to teach us about changes to our main islands over time?
- What is the change that we need to make in ourselves to keep our islands healthy?

2. Show some of the photos from the photo CD (provided with this guide) of researchers studying the NWHI. Explain that scientists from the Northwestern Hawaiian Islands Reef Assessment and Monitoring Program (NOWRAMP) conducted expeditions to the NWHI to find out what we could learn from these older islands. The expeditions included scientists who surveyed the land and marine environment.

3. Explain that students are going to take on the role of those scientists by taking an imaginary expedition to the NWHI. Divide the class into the following five teams: Land Team, Fish Team, Coral Team, Ocean Invertebrate Team, and Limu (Algal) Team. Before going on the expedition, read the incomplete hypotheses on the top of the expedition sheets to the teams. Ask each student on a team to generate a testable hypothesis by completing the statement (e.g., the population of seabirds on the beach will be larger, the populations of fish will be larger, the size of fish will be larger, the number of species will be fewer or greater, etc.). Discuss what makes a hypothesis testable.

4. Distribute the expedition sheets. Ask students to count off from 1 to 5 in their groups and write their own numbers on the top of individual sheets. (This will be their group number when they switch groups to do a jigsaw sharing.)

5. Ask students to take turns reading the information out loud to others in their group. As they are reading, have them refer to the images of the organisms and the islands on the photo CD. Have students work together to answer the questions on their sheets. Instruct all students to write answers because each member will be responsible for sharing his/her new expertise when students switch groups.

6. Visit each group to ensure that students' answers are accurate and that each student has recorded the answers. Ask students to switch groups by having all students with the number 1 gather in one area, number 2 in another area, and so on. Each group should be composed of five students representing each of the five teams on the expedition. If the number of students does not equally divide into groups of five, extra students should be assigned to an existing group as a second expert. Incomplete groups should not be formed.

7. Ask students to take turns sharing their information with their new group. Students should share their hypotheses and the conclusions that the team has drawn from the expedition. In groups where there are two specialists for one area of expertise, students should be instructed to split the task in half. Encourage them to share images from the photo CD as well.

8. Once every student has shared his/her expertise with the group, distribute the summary sheet and ask students to complete it.

9. Ask student teams to identify one major difference between the NWHI and the MHI. Ask them to also name one similarity between the two groups of islands. An answer could be elicited by asking students to complete the sentence: "Both the NWHI and the MHI are/have_________."

10. Distribute the Venn diagram sheet and ask students to compare the similarities and differences between the NWHI to the MHI using the information from their summary sheets.

11. Have students complete the assessment by recording their hypotheses in their journals and describing how the expedition studied the plants or animals. Fifth grade students should include the evidence they used to formulate conclusions from the expedition.

Extended Activities

Challenge groups of students to learn more about the land, coral reefs, or ocean life of a particular island. Have them research the island's history and add information about how the land, coral reefs, and ocean life have changed over time as a result of human presence. See the Appendix for a timeline of significant events in the NWHI. In addition, refer to the Navigating Change photo CD for images from Units 2 and 3 that students may want to use in their reports. Students may also want to check out the following web sites for more information.

- Navigatingchange.org
- Hawaiianatolls.org
- http://www.hawaiireef.noaa.gov/about/welcom.html

Take students to the Hawai`i Maritime Center where they can go on a simulated expedition to the NWHI. At the center, students will visit a life-sized model of an atoll and assume the role of scientists on an expedition. Call 523-6151 to schedule a field trip.

Student Expedition Sheet: Land Team

Geographic Area: Northwestern Hawaiian Islands (NWHI)

Name ______________________

No. ______________________

Complete this hypothesis: Compared to the main Hawaiian Islands, the populations of seabirds and turtles on the beaches of the NWHI will be…

Imagine that you are one of the 50 scientists departing for an expedition to the "kūpuna" islands. Your mission is to study the plants and animals on land in these NWHI. The data you collect will guide how these islands will be managed in the future. These "kūpuna" islands are the older islands; they have much to teach us. So, let's go!

Our expedition will include the following teams: Land Team, Fish Team, Coral Team, Invertebrate Team, and Limu (Algal) Team. As a member of the land team, you are working together with scientists who study both plants and animals. Your team conducts surveys on all of the emergent (above sea level) areas of the NWHI. Check your map of the islands, which have emergent areas that you'll be landing on? You are going to be tasked with counting the different kinds of plants you see, seabird eggs and chicks, rare land birds, and the green sea turtles and monk seals basking on the beaches. To do a complete job of counting you must figure out how your team of scientists is going to walk the entire area of the island. One way this can be accomplished is by teaming up with a partner and walking next to each other down the middle of the island. Your partner can cover all the land on his right and you can cover all the land area on your left. You will need to count all the eggs and chicks whether they are nesting underneath the ground in a burrow, right on top of ground, or up in a bush.

Don't forget you will be noting the different kinds of plants you see while you are counting all those seabird nests. You can easily put a check mark on a photo plant identification list you carry with you. It is important to take a sketch pad of paper along with you to draw plants that are not on your list. You can use the drawings to identify the plants later. And you should also note any alien insects that you might see.

Scientists compare their count numbers from year to year so they know whether populations are increasing or decreasing. If the numbers increase year after year that is good sign of a healthy ocean that can provide food for millions of seabirds, and hundreds of green sea turtles and monk seals.

Native Species

Making it through the surf and up the steep cliffs of Nihoa is very challenging! But the effort is worth it! As soon as you land on shore you will be surrounded by thousands of seabirds and upon a closer look you see very rare land birds flitting by. You must complete your counts as quickly as possible so as not to scare away nesting adult birds that are protecting their eggs and baby chicks from the hot burning sun. At the same time you must walk carefully and watch where you step. The weight of your body can trap a baby chick in a nesting underground burrow.

Your team finds native plants and animals on every square foot of this deserted island. There are three endangered plant species, including the Nihoa fan palm. In addition to the thousands of seabird nests you also count the number of individual rare land bird species you see. The endangered Nihoa finch population is about 1,000 birds. And there are about 200 Nihoa millerbirds. These rare birds are endemic to this island.

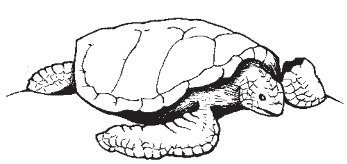
On Laysan, the Laysan duck relies on the salty lake in the middle of the island for habitat. It's the smallest range of any duck in the world! But from fossil studies, you know that this endangered bird had a much larger range. It was once found at Mōkapu on O`ahu. In general, land birds are rare on these islands. There is very little fresh water and habitats for land birds are limited.

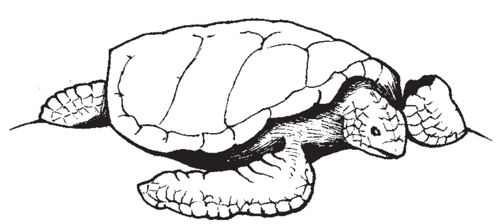
Seabirds are the most abundant birds on the islands. The "kūpuna" islands are the largest tropical seabird rookery in the U.S., and perhaps the world. Millions of resident seabirds belonging to more than 20 species nest on the islands. Thousands of migratory shorebirds also spend the winter here. It is so different from beaches at home where seabirds are never seen in such large numbers. Native Hawaiian monk seals and green sea turtles rely on these islands for habitat as well. The monk seal is critically endangered with a population of only about 1,400. They are one of the most critically endangered marine mammals in the entire U.S. When you survey Native French Frigate Shoals, you see the beaches where more than 90% of all Hawaiian green sea turtles are born! They range throughout the state, but this is where most come to nest. At home it is a rare treat to spot either of these animals resting on a beach.

Alien Species

Your team discovers alien (non-native) insects on all islands. You find that alien insects are a big problem on Kure and Midway where big-headed ant populations are huge. At Kure Atoll you find that there are 26,500 alien ants per square meter! There are no predators for these ants. These alien insects are efficient predators with very few limits on their diet. They can prey on native insects that have no defenses against them. They also disturb ground-nesting seabirds in their burrows, and can invade the eyes of vulnerable, newly hatched seabirds. One of your team calls these ants "ecosystem-busters."

A few alien plants are found on all islands except Gardner Pinnacles. To prevent these plants from taking over the native plants, you carefully pick them. But you leave plants with dried seeds that could fly off and reseed somewhere else on the island.





Drawing Conclusions from the Expedition: Land Team

Was your hypothesis validated by the expeditions's findings?

Which animal species are more common on beaches in the NWHI than the main Hawaiian Islands (MHI)?

Which endangered and threatened species are found on French Frigate Shoals? Why is this an important habitat?

What are some of the rare land species you find in the NWHI? Why do you think they are rare?

Most of the NWHI you visit are not typical islands. Some islands are just submerged banks; others are atolls or low coral islands. Many do not have a natural fresh water supply. This makes it difficult for even researchers to live there. From notes of earlier expeditions, you realize that these atolls and low coral islands are constantly changed by coral growth, erosion, and tides. Review the data in the table on the following page and find:

- the island with the largest natural land area
- the island with smallest land area
- the island with the largest submerged coral reefs

The "Kūpuna" Islands - Land Area and Submerged Coral Reefs

Island	Land Acres	Submerged Coral Reef (acres)	Characteristics
Maro Reef	Less than 1	458,540	• Totally submerged most of the time • Less than an acre of coral emerges from the water at low tide.
Nihoa Island	171	142,000	• Has two peaks and steep sea cliffs • 88 known cultural sites from Hawaiians who inhabited the island between 1000 and 1700 AD
Necker Island	46	380,000	• Geologists believe it was once as large as O`ahu. • At its highest point, it rises 365 feet above the sea.
French Frigate Shoals	67	230,000	• Small sandy islets are continually submerged and uncovered as waves and currents shift the sand.
Gardner Pinnacles	5	600,000	• The exposed part of the island appears as two rocks jutting from the surface of the sea. The largest one is 180 feet high and 590 feet in diameter. • Most of the coral reefs are in waters deeper than 60 feet.
Laysan Island	1,015	145,334	• A small portion of the reef is in shallow water but most of it is in deep water. • A hypersaline (very salty) lake is in the interior of the island.
Lisianski Island	395	241,916	• Its highest point stands 40 feet above water.
Pearl & Hermes Atoll	89	300,000	• The land is divided among many small islets piercing the water surface.
Kure Atoll	200	80,000	• Green Island is found on the edge of the lagoon.
Midway Atoll	1,535	85,929	• Two islands – Sand and Eastern – and a small island called Spit Island are above the surface of the water.

Adapted from Coral Reef Ecosystems of the Northwestern Hawaiian Islands, NOAA. Northwestern Hawaiian Islands: A Resource Guide, and NODC Unit Conversion Guide, NOAA at http://www.nodc.noaa.gov/dsdt/ucg/

Student Expedition Sheet: Fish Team

Geographic Area: Northwestern Hawaiian Islands (NWHI)

Complete this hypothesis: Compared to the main Hawaiian Islands, the fish in NWHI will be…

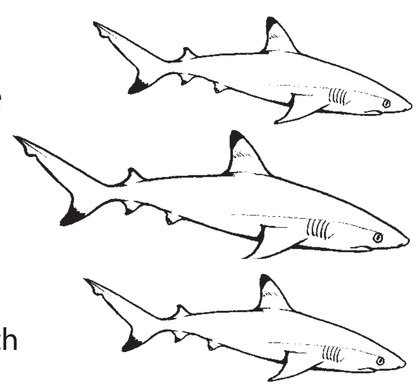
Name ______________________
No. ______________________

Imagine that you are one of the 50 scientists departing for an expedition to the Northwestern Hawaiian Islands. Your mission is to study the plants and animals on land and in the waters surrounding the NWHI. The data you collect will guide how these islands will be managed in the future. These "kūpuna" islands are the older islands; they have much to teach us. So, let's go!

Our expedition will include the following teams: Land Team, Fish Team, Coral Team, Invertebrate Team, and Limu (Algal) Team. As a member of the fish team, you are working together with a few teams. The first team to go out when you reach the NWHI is the towboard team. Two trained divers are towed behind a boat with video cameras to record the ocean habitat. The towboard team helps the rest of you figure out the best areas to study. Then teams of three divers swim along a line (called a transect) to study the fish. They count different species of large fish within 2 meters of each side of the line. On the swim back along the line, they count the small fish.

Large Numbers of Predators

When you dive into the water, the first thing that you notice is the number of large fish such as sharks (manō), jacks (ulua), and amberjacks (kahala). These are apex predators, which means they feed at the apex (top) of the food chain.



When you dive at Pearl and Hermes Atoll, you and your team are surrounded by over 300 jacks (ulua)! A "big daddy" ulua, a giant trevally, bites at some of the divers' hands. In one of the dives at Kure Atoll, 30 Galapagos sharks are counted in a single pass! When you dive off the MHI you do not often find large numbers of big predators, and if you do, they usually swim away. Here there are lots of large predators and they seem to be attracted to your team.

Big Fish

Other big fish that you observe are Hawaiian hogfish (`a`awa), bigeye emperor (mū), and spectacled parrotfish (uhu uliuli). You find these fish in large numbers and you notice that they are easily approached. When you dive in the MHI, you see much fewer of these fish and they aren't as large! These species also swim away when you find them in the waters at home. The spectacled parrotfish (uhu uliuli), which is a favorite food fish of many, has really suffered from overfishing. From your surveys, you discover that the abundance of uhu is more than 700% greater in the NWHI than in the MHI. This means that for every parrotfish seen in the MHI, more than 7 are seen in the NWHI!

Other Interesting Finds

Other interesting finds include the cardinal fish, which is common here but rarely seen in the MHI. You also observe the chevron butterflyfish feeding on table corals. This fish is rare in the MHI since its food source is rare there. Another discovery are the giant groupers (hāpu`upu`u) swimming in shallow water off Midway and Kure atolls. These endemic fish approach and follow right behind you in the water. At home, due to overfishing, it's rare to see a giant grouper. And when you do see a grouper, they are usually at depths of about 300 feet.

Drawing Conclusions from the Expedition: Fish Team

Was your hypothesis validated by the expedition's findings?

When you summarize your data, you find that the average fish biomass (total weight of living things in a defined area) in the NWHI is nearly three times greater than in the MHI. Why do you think there is such a difference?

What is different about the apex predators you observe in the NWHI compared to these predators in the MHI? Why do you think there is this difference?

What do you notice about the behavior of some of the fish that is different from the fish at home? Why do you think it is different?

What lessons we can learn from the "kūpuna" islands to help us manage our coral reefs at home?

Student Expedition Sheet: Invertebrate Team

Geographic Area: Northwestern Hawaiian Islands (NWHI)

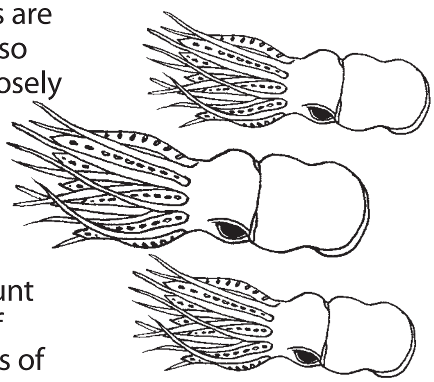
Name ____________________

No. ____________________

Complete this hypothesis: Compared to the main Hawaiian Islands, the invertebrates in the NWHI will be…

Imagine that you are one of the 50 scientists departing for an expedition to the Northwestern Hawaiian Islands. Your mission is to study the plants and animals on land in these NWHI. The data you collect will guide how these islands will be managed in the future. These "kūpuna" islands are the older islands; they have much to teach us. So, let's go!

Our expedition will include the following teams: Land Team, Fish Team, Coral Team, Invertebrate Team, and Limu (Algal) Team. As a member of the invertebrate team, you are working together with a few other teams. Corals are invertebrates, too, so you are working closely with that team. When you reach the NWHI, the first team in the water is the fish team. They count different species of fish within 2 meters of each side of a transect line. After the fish team completes its dive, your invertebrate team dives in to study the invertebrates. You swim along the same transect line as the fish team and record what you find. You collect specimens, take photographs, and record video.

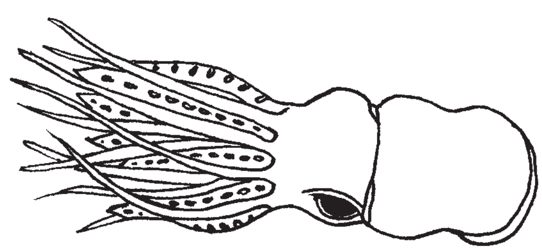


You are excited when you dive in the NWHI because there are so many invertebrates (animals without backbones, such as sponges, lobsters, crabs, and snails) that you have never seen before in your dives at home! When you dive around Nihoa and Necker you find groups of invertebrates that are different from the species you find at the atolls. In Shark Bay at Necker Island, you find lots of different species of sea cucumbers and sea urchins, and lobsters are common.

The atoll lagoons at Pearl and Hermes Reef and French Frigate Shoals provide a unique habitat for new species to evolve. At French Frigate Shoals you discover lots of clams that you have never seen in the MHI. You and your team also collect snails, crustaceans, and sponges that have never been seen before in the MHI. Of the 75 sponge species you collect, 60 are new records for the Hawaiian Islands! On one dive at Pearl and Hermes Reef, one of your team collected a variety of sponges. Seven of those were thought to be new species. It was quite a discovery for a single dive!

You observe more crown-of-thorns seastars feeding on corals than you see in the MHI.

You also observe giant `opihi around Gardner Pinnacles! These endemic giant limpets have just about disappeared from the MHI. It is also rare to find concentrations of smaller `opihi in the MHI since they are valued as a delicious food.



Drawing Conclusions from the Expedition: Invertebrate Team

Was your hypothesis validated by the expedition's findings?

What do you discover about the `opihi (limpets) in the NWHI that is different from the MHI? Why do you think there is such a difference?

Why do you think there are different invertebrates around Nihoa and Necker compared to the lagoons in the atolls?

What did you find in the lagoons in the atolls that does not occur in the MHI?

What have we learned from studying invertebrates in the "kūpuna" islands that could help us manage coral reefs in the MHI?

Student Expedition Sheet: Coral Team

Geographic Area: Northwestern Hawaiian Islands (NWHI)

Complete this hypothesis: Compared to the main Hawaiian Islands, the coral in the NWHI will be…

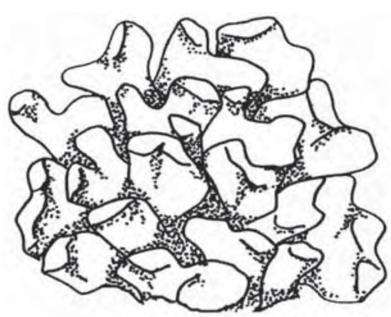
Name ______________________

No. ______________________

Imagine that you are one of the 50 scientists departing for an expedition to the Northwestern Hawaiian Islands. Your mission is to study the plants and animals on land and in the water surrounding the NWHI. The data you collect will guide how these islands will be managed in the future. These "kūpuna" islands are the older islands; they have much to teach us. So, let's go!

Our expedition will include the following teams: Land Team, Fish Team, Coral Team, Invertebrate Team, and Limu (Algal) Team.

As a member of the coral team, you are working together with a few other teams. Since corals are also invertebrates, you work closely with that team. When you reach the NWHI, the first team in the water is fish team. They count different species of fish within 2 meters of each side of a transect line. After the fish team completes its dive, your coral team dives in to study the corals. You swim along the same transect line as the fish team and record what you find. You collect specimens, take photographs, and record video.



As soon as you enter the water, you are amazed by how many different kinds of corals you see. There are many large stony coral colonies—55 species in all! At least three, and possibly as many as six, of the stony coral species may be new discoveries for Hawai`i. In the waters of Kure and Maro you see many large disk corals, table corals, and finger corals. The atoll lagoons are where you find most corals. These lagoons are protected from wave action and they have lots of habitats. The colorful corals and fish in these peaceful waters are beautiful. At French Frigate Shoals you find the greatest number of coral species in the NWHI, including two new species of Acropora table corals.

Later, when you study the pictures you took, you realize that 10 of the 55 species you found have never been seen in the NWHI before. Also, 12 of the species you found have never been seen in the MHI. It's amazing that there are more species of corals in the NWHI than there are in the MHI. Corals grow best in warm waters, and as you head north, the water temperature is cooler. So it is strange to see more coral species in the cooler water at the NWHI than in the warmer water at the MHI.

Drawing Conclusions from the Expedition: Coral Team

Was your hypothesis validated by the expedition's findings?

What do you discover about the corals in the NWHI that is different from the MHI? Why do you think there is such a difference?

Why do you think the lagoons in the atolls are where you found most coral species?

What did you find in the lagoons in the atolls that does not occur in the MHI?

What have we learned from studying corals in the "kūpuna" islands that could help us manage coral reefs in the MHI?

Student Expedition Sheet: Limu Team

Geographic Area: Northwestern Hawaiian Islands (NWHI)

Name ________________

No. ________________

Complete this hypothesis: Compared to the main Hawaiian Islands, the limu in the NWHI will be

Imagine that you are one of the 50 scientists departing for an expedition to the Northwestern Hawaiian Islands. Your mission is to study the plants and animals on land in these NWHI. The data you collect will guide how these islands will be managed in the future. These "kūpuna" islands are the older islands; they have much to teach us. So, let's go!

Our expedition will include the following teams: Land Team, Fish Team, Coral Team, Invertebrate Team, and Limu (Algal) Team.

As a member of the limu team, you are working together with a few other teams. When you reach the NWHI, the first team in the water is the fish team. They count different species of fish within 2 meters of each side of a transect line. After the fish team completes its dive, your limu team dives in to study the limu. You swim along the same transect line as the fish team and record what you find. You collect specimens, take photographs, and record video.

As you enter the lagoon at French Frigate Shoals, the first thing you notice is that there are so many different types of limu! On dives in the MHI, you have seen more and more alien limu taking over the reefs, crowding out the native species. These reefs in the NWHI are healthy and diverse. At French Frigate Shoals, you find many limu species that you know have not been recorded there before. Most species are red algae, which is typical for tropical waters. You carefully collect specimens of each species that you will examine under the microscope later on. This lab work is necessary to positively identify the different limu species.

As you walk along the sand at the edge of the lagoon on French Frigate Shoals, there is a crunching sound. You stop to check out the dried green algal chips under your feet. The sand here is made up of large patches of green algae. The algae encase themselves in calcium carbonate, which is the same substance that shells are made of. There are many more of these algal chips in the sand here than what you have seen in the MHI.

After you return from the expedition you study your specimens in the lab. From the specimens you brought back from French Frigate Shoals you discover four species of red algae that are totally new to science! Two limu species are new to Hawai`i and 70 are new to French Frigate Shoals. Additionally, you have also uncovered 28 new species of green algae and 10 new species of brown algae. Your dive at French Frigate Shoals increased the known limu species for that location by almost ten times, or 1000%.

Drawing Conclusions from the Expedition: Limu Team

Was your hypothesis validated by the expedition's findings?

What do you discover about limu in the NWHI that is different from the MHI? Why do you think there is such a difference?

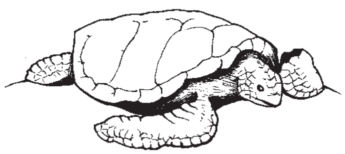
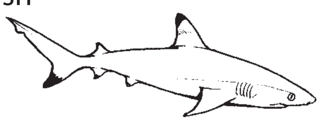
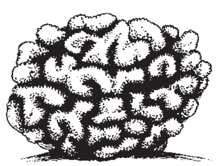
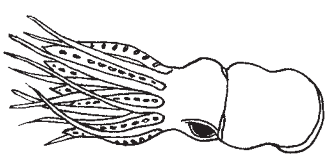
Why do you think the lagoons in the atolls are where you found most limu species?

What did you find in the lagoons in the atolls that does not occur in the MHI?

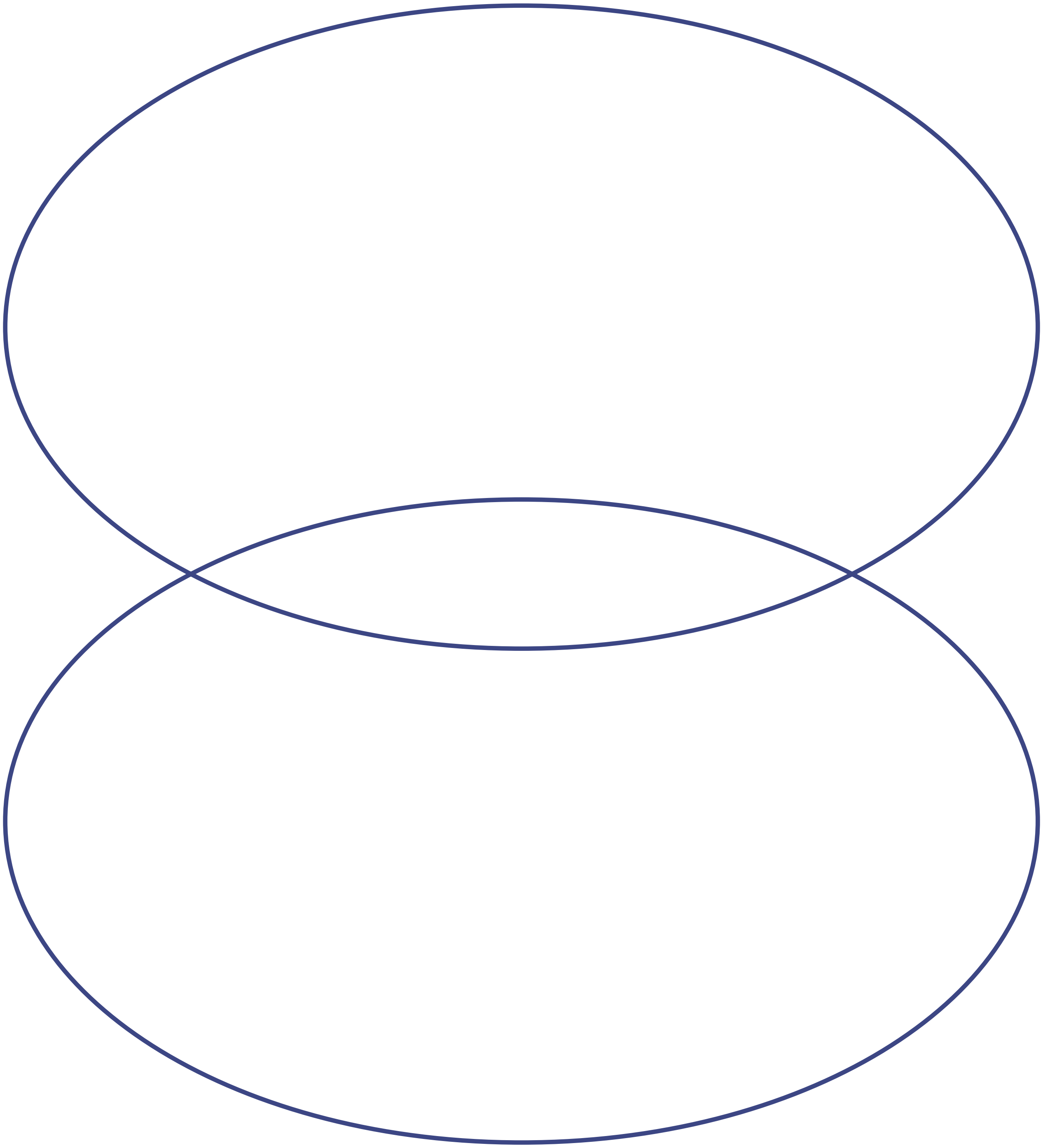
What have we learned from studying limu in the "kūpuna" islands that could help us manage coral reefs in the MHI?

Student Summary Sheet

Summarize what you have learned from the expedition about the differences between the NWHI and MHI for each of the areas the five teams investigated.

	NWHI	MHI
Land 		
Fish 		
Coral 		
Other Invertebrates 		
Limu 		

Venn Diagram



Looking Back

Essential Question: How has the coral reef in our community changed over time?

Hawai`i DOE Content Standards and General Learner Outcome (GLO)

Social Studies 7: Geography: World in Spatial Terms – Environment and Society

- Use geographic representations to organize, analyze, and present information on people, places, and environments and understand the nature and interaction of geographic regions and societies around the world.

Science 2: The Scientific Process: Nature of Science – Unifying Concepts and Themes

- Understand that science, technology, and society are interrelated.

GLO 5 Effective Communicator: The ability to communicate effectively

Grades 4 - 5 Benchmarks

Social Studies

4.7.3 Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations.

Science

5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

GLO 5 Listens to, interprets, and uses information effectively

Nā Honua Mauli Ola #8 - 12

Engage in activities independently or collaboratively with community members to perpetuate traditional ways of knowing, learning, teaching, and leading to sustain cultural knowledge and resources within the learning community.

- Learners are able to pursue opportunities to observe and listen to expert resources within the community.

Key Concepts

- The coral reefs of the NWHI provide a baseline to see how reefs in the MHI have changed due to human activities.
- Interviewing elder fishers and other resource people in the community is one way to learn about how the coral reefs have changed over time.

Activity at a Glance

Students develop interview questions and practice interviewing skills before talking to elder fishers, kūpuna, and other resource people to learn more about how the reef in their community has changed over time.

Time

3 - 4 class periods

Assessment

Students:

- Add information to their Venn diagram comparing the NWHI and the MHI.
- Summarize their conclusions about how human activities have affected coral reefs around the main Hawaiian Islands.
- Develop diagrams, sketches, or graphs as models to represent how the coral reef in their community has changed over time.

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Evaluate the consequences of human modification of the physical environment in Hawai`i using geographic representations, drawing relevant and insightful conclusions.	Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations, drawing relevant conclusions.	Describe the consequences of human modification of the physical environment in Hawai`i using geographic representations.	Recognize, with assistance, the consequences of human modification of the physical environment in Hawai`i using geographic representations.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world.	Use models and/ or simulations to represent and investigate features of objects, events, and processes in the real world.	With assistance, use models or simulations to represent features of objects, events, or processes in the real world.	Recognize examples of models or simulations that can be used to represent features of objects, events, or processes.

Vocabulary

apex predators – carnivorous animals at the top of the food chain, like sharks and ulua

baseline – information collected about an ecosystem at a known point of time that creates a "picture" for measuring change in the future

biomass – total weight of living things in a defined area

ecosystem – a system of interactions between living organisms and their physical environment

herbivores – animals that feed on plants

low-level carnivores – animals, smaller than apex predators, that feed on organisms lower in the food chain

reproductive maturity – age or size at which an organism is able to reproduce

shifting baseline – using information recorded at a different time as a baseline by which to measure change

Materials

- Comparing Reefs PowerPoint presentation (provided on photo CD)
- acetate sheets (to make overheads if computer projection is not an option)
- Venn diagram (provided in previous activity)
- Navigating Change video segment "Change Over Time"

Advance Preparation

If you do not have the technology that enables you to project the PowerPoint presentation provided on the photo CD, print each slide and make overhead transparencies. (Note: A copy of the Power Point slide show is included after this lesson.)

Background Information

If we dive into the water to study the reefs around our main islands today, how do we know how much the reefs have changed over time? What is the point of reference we can use to determine how much change has taken place? We all hear stories from community elders about how plentiful the reefs used to be, and from time to time there are articles in the news about declining commercial fish catch. One way that we can assess change is to use a baseline as a reference point for measuring change in ecosystems over time or for measuring the effects of a particular impact, like fishing, or pollution. If the change being measured is in response to something in particular, like human activities, a baseline from before these activities took place is needed to form a true picture of the change.

Two baselines can be used to assess the health of the MHI ecosystems. First, the MHI of today can be compared to the baseline from previous decades. Second, as students learned in the previous activity, the NWHI offer a baseline that probably resembles what ecosystems of the MHI looked like before humans inhabited the islands.

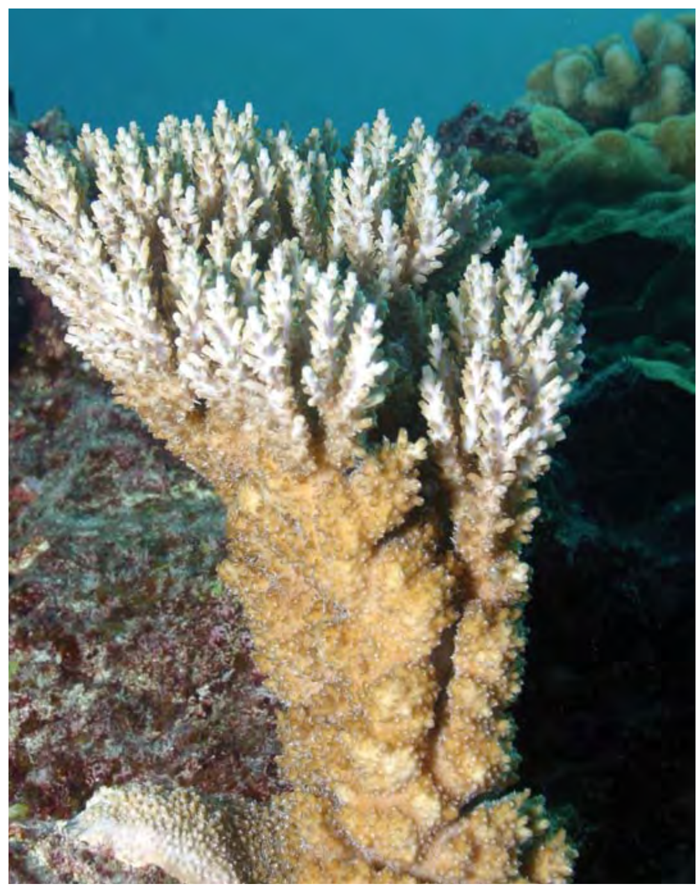
From generation to generation, there is a tendency to shift baselines. If the new generation is unaware of a previous baseline, it can end up perceiving a degraded ecosystem as normal or even as an improvement. Awareness of the original baseline is essential to understanding the impact humans have on the environment and to taking restorative actions before it is too late. By comparing baselines of the MHI 100 years ago with information collected today, we know that the current fish stocks are at most 20-25% of what they were 100 years ago! Most alarming is the fact that this reduction in numbers and size of the fish has been documented in oceans worldwide. In this lesson, students reach out to elders in their community to collect information on how our coral reefs have changed.

Teaching Suggestions

1. Ask students if they think the coral reefs around their island have changed over the last 100 years. How do they know? What is the evidence of change? Discuss ways that we can find out how much change has taken place.
   - Compare data – fishing records of amount of fish caught
   - Talk to older fishers to hear their accounts of how their fish catch has changed
   - Ask scientists who study reefs to share information they have collected
   - Compare the NWHI reefs with our MHI reefs to get an idea of what reefs in areas of less human impact are like.

2. Introduce the concept of a baseline. Have students imagine that the class is a coral reef ecosystem and that each member of the class represents a fish in the ecosystem 100 years ago. What is the total population of fish? Use that population as the baseline—the reference point. Now imagine that 50 years have gone by and that the fish population is decreasing due to more and more fishing. Have 10 students step to the side of the class. What is the population now? Allow 50 more years to go by and remove 12 more "fish." Take a count of the fish population again. How much has the fish population changed?
   <u>Discussion Questions</u>
   - If we didn't have our original baseline, would we know how much change there had been in our coral reef? (No, we might only have a general idea that there weren't as many fish as there used to be.)
   - If we only had the population of fish from 50 years ago, would that be enough of a baseline to measure change? (It only gives a partial picture. This is what we call a shifting baseline.)
   - How do you think the reefs in the NWHI provide us with a baseline to measure change? (They offer a baseline that probably resembles what ecosystems of the MHI looked like before humans inhabited the islands.)

3. Show the PowerPoint presentation about comparing coral reef ecosystems and discuss the information with students. Point out the pie charts showing the differences in biomass for apex predators, low level carnivores, and herbivores in the NWHI and MHI. Discuss how these charts are an effective way to represent these differences.



4. If you have not already done so, show students the Navigating Change video segment, "Change Over Time." Discuss differences and similarities between the NWHI and the main Hawaiian Islands.

5. Discuss ways that students could collect information in your community to learn about change in local reefs over time. Make a list of people that students might approach to request interviews, including uncles, aunties, kūpuna, fishers, researchers, and resource managers.

6. Challenge each student to interview a community member to learn more about how the nearest coral reef has changed over time. Ask students to decide on whom they will approach for an interview and what kinds of questions they will ask during the interview.

7. Have students submit their questions for peer review by their classmates and discuss what makes good interview questions, i.e., questions that are open-ended, requiring more than a "yes" or "no" response, and questions that focus on the information students wish to learn.

8. Discuss ways to approach people to request an interview and key points to remember when conducting an interview.
   Conducting Interviews – Key Points:
   - Arrive at the scheduled time.
   - Be polite and respectful.
   - Take notes and repeat key points to clarify information heard.
   - Thank the interviewee at the end of the interview, and also with a follow-up note.

9. Once students have conducted their interviews, discuss what they have learned. How much of the information is factual and how much is opinion? What have they learned about the change in the reef over time? Ask them to summarize their information in their journals and include diagrams or sketches to show how the reef has changed. Ask students to share their representations with their classmates.

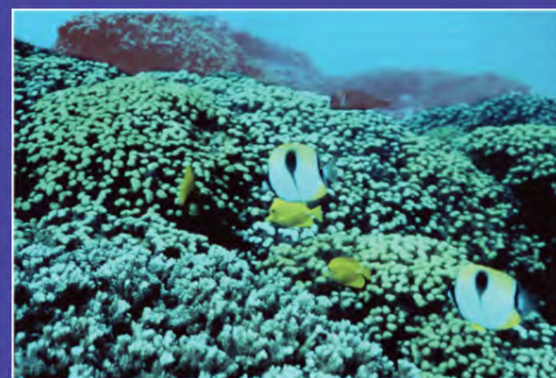
10. Have students add new information to their Venn diagrams. The culminating activity for this unit challenges students to come up with creative ways to share what they have learned with others in the school or community. One of the field-testing classes worked with elders in their community on a culminating activity to paint a mural showing how their reef contrasted with a reef in the NWHI. The mural became a focal point that generated lots of interest in the community.

Extended Activity

In groups of four, have students research one organism that is present in both the NWHI and the MHI and create a short PowerPoint presentation to share with the class. Provide them with the Navigating Change photo CD as a resource. Students may want to check out the following web sites for more information.

- Navigatingchange.org
- Hawaiianatolls.org
- www.shiftingbaselines.org

Comparing Coral Reefs
How are they different?



How do we know what our coral reefs in the MHI used to looked like?

- •Talk to people who have observed changes over time (e.g. kūpuna, grandparents).
- •Read books that were written in the past (e.g. Captain Cook’s journal entries).
- •Compare the MHI with a similar environment that has not been heavily changed by humans (NWHI).
- •Learn from Hawaiian oral history and chants, and from scientific records and research.

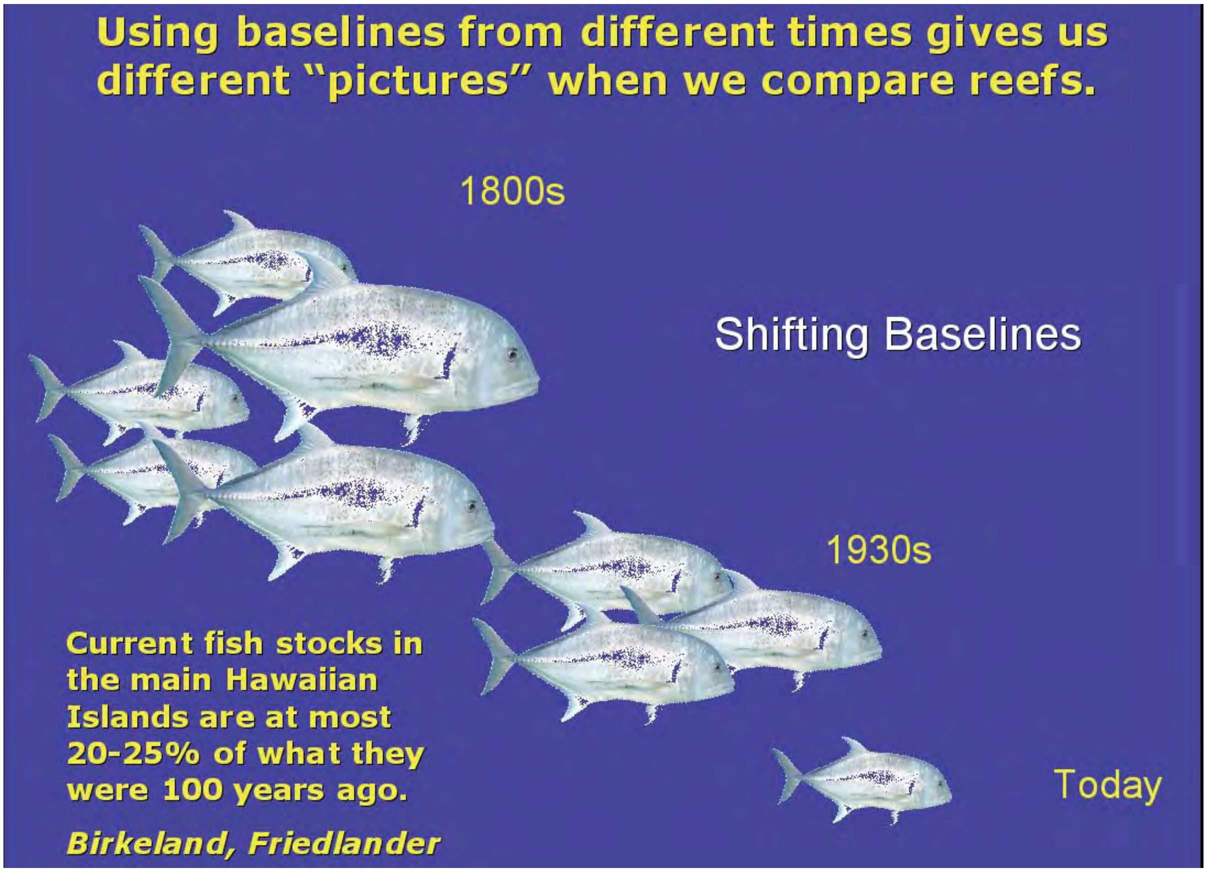
What is a baseline?

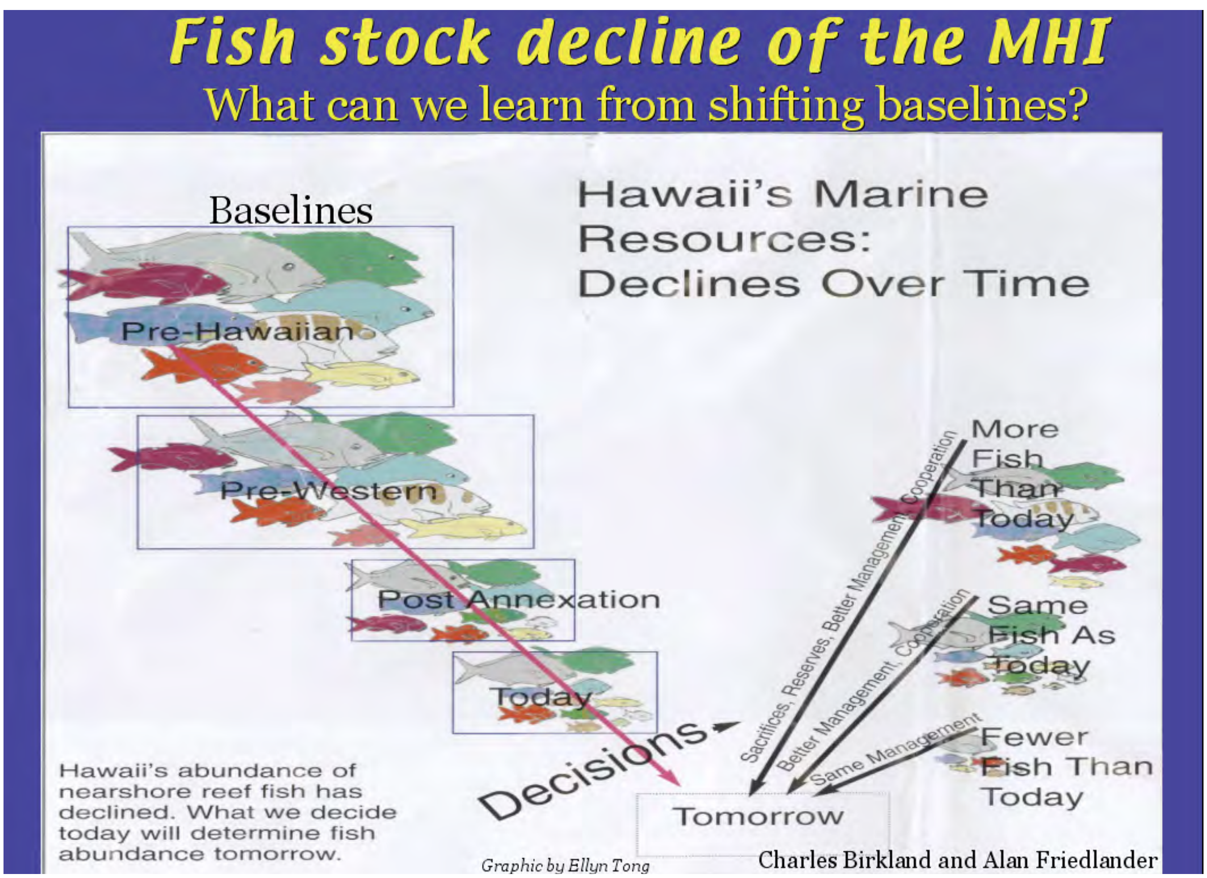
A baseline is information collected about an ecosystem, like a coral reef, at a known point in time. It creates a "picture" for measuring change in the future.

Baselines...

- provide information to understand changes in our reefs over time.

- help us to understand how we can work toward restoring damaged reefs.


Using baselines from different times gives us different "pictures" when we compare reefs.
1800s
Shifting Baselines
1930s
Today
Current fish stocks in the main Hawaiian Islands are at most 20-25% of what they were 100 years ago.
Birkeland, Friedlander


Fish stock decline of the MHI
What can we learn from shifting baselines?
Baselines
Hawaii's Marine Resources: Declines Over Time
Pre-Hawaiian
Pre-Western
Post Annexation
Today
Decisions
Tomorrow
Sacrifices, Reserves, Better Management, Cooperation
Better Management, Cooperation
Same Management
More Fish Than Today
Same Fish As Today
Fewer Fish Than Today
Hawaii's abundance of nearshore reef fish has declined. What we decide today will determine fish abundance tomorrow.
Graphic by Ellyn Tong
Charles Birkland and Alan Friedlander

How can we compare ecosystems?

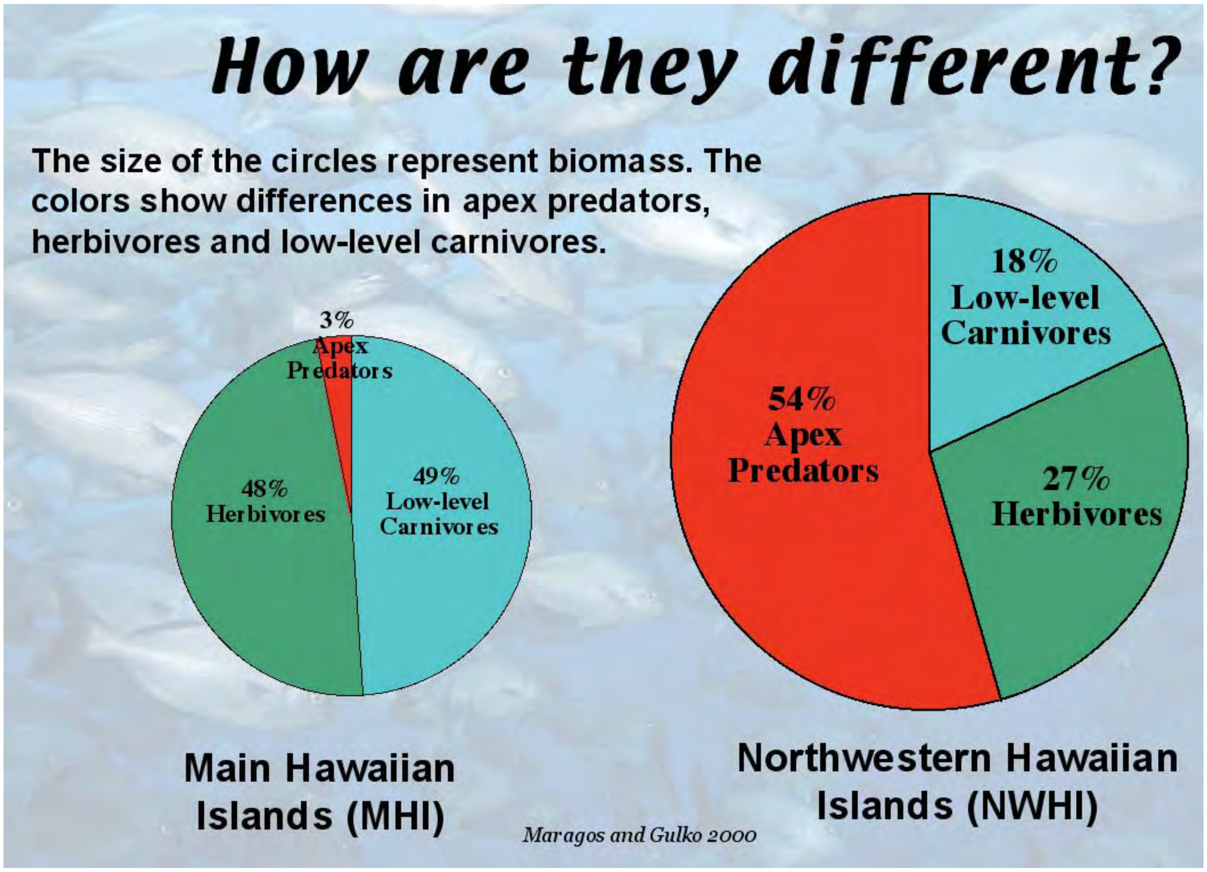
Marine Ecosystem of NWHI vs **Marine Ecosystem of MHI**

- Number and size of fish?
- Coral cover and health of coral reefs?
- Number of native vs. alien species?
- Populations of monk seals, turtles, birds?

What is Biomass?

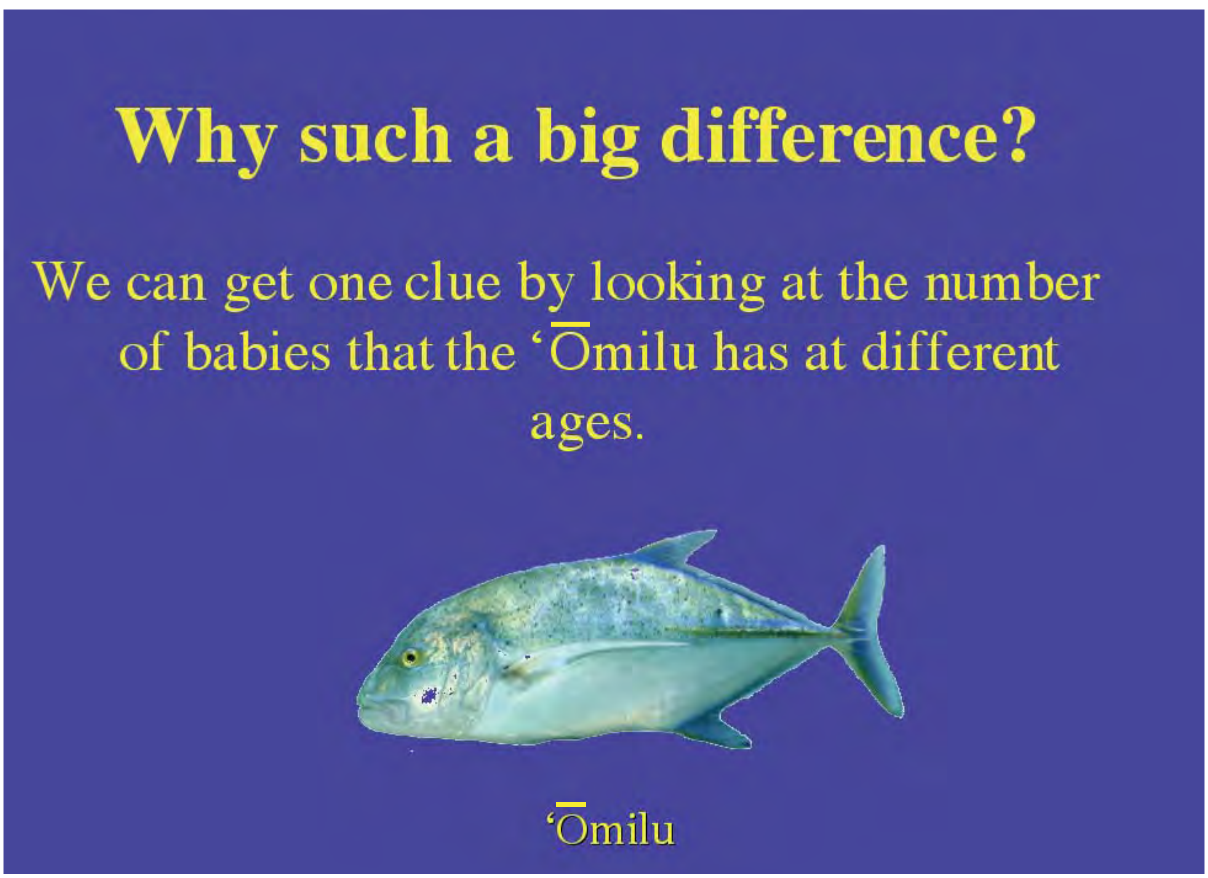
Biomass is the total weight of living things in a defined area.

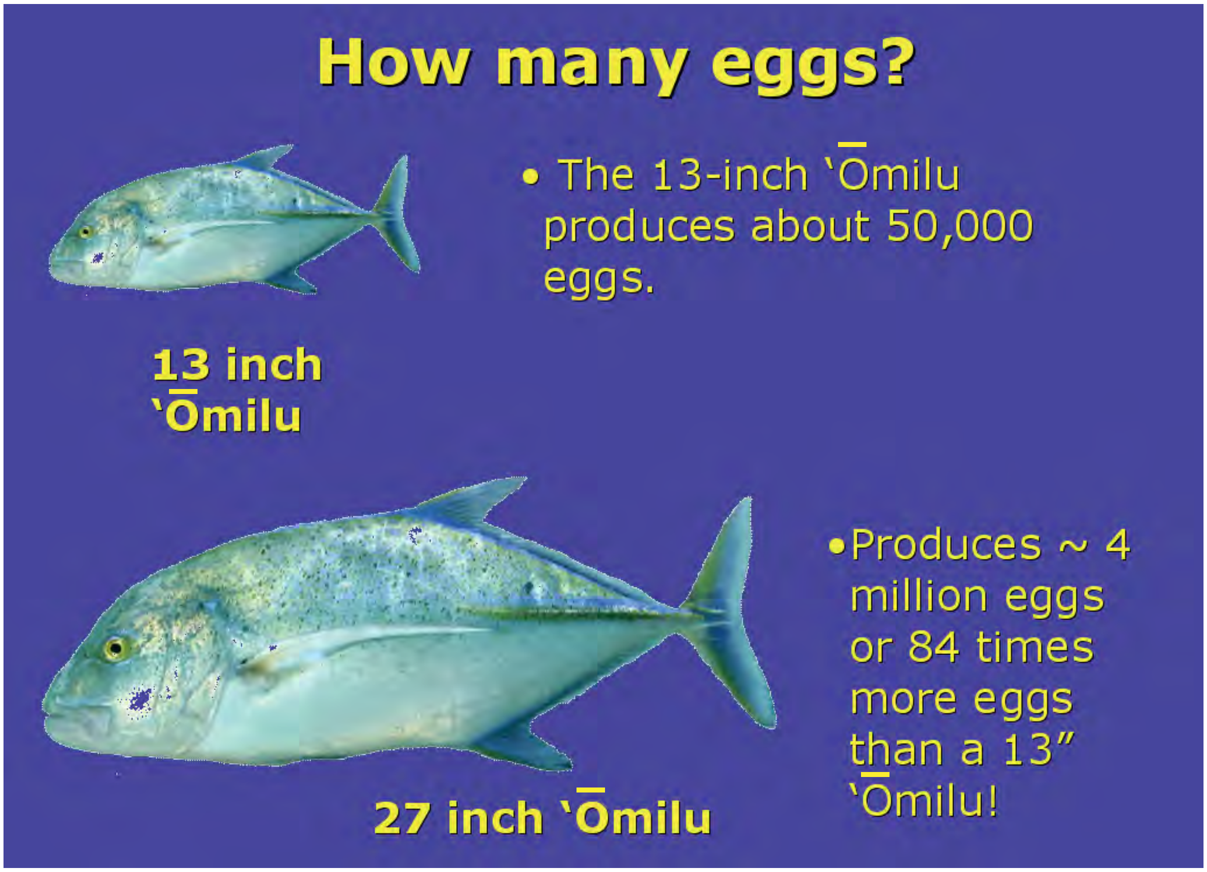
- *The biomass of fish in the waters of the NWHI = the total weight of all the fish that swim in a measured area of the waters of the NWHI.*

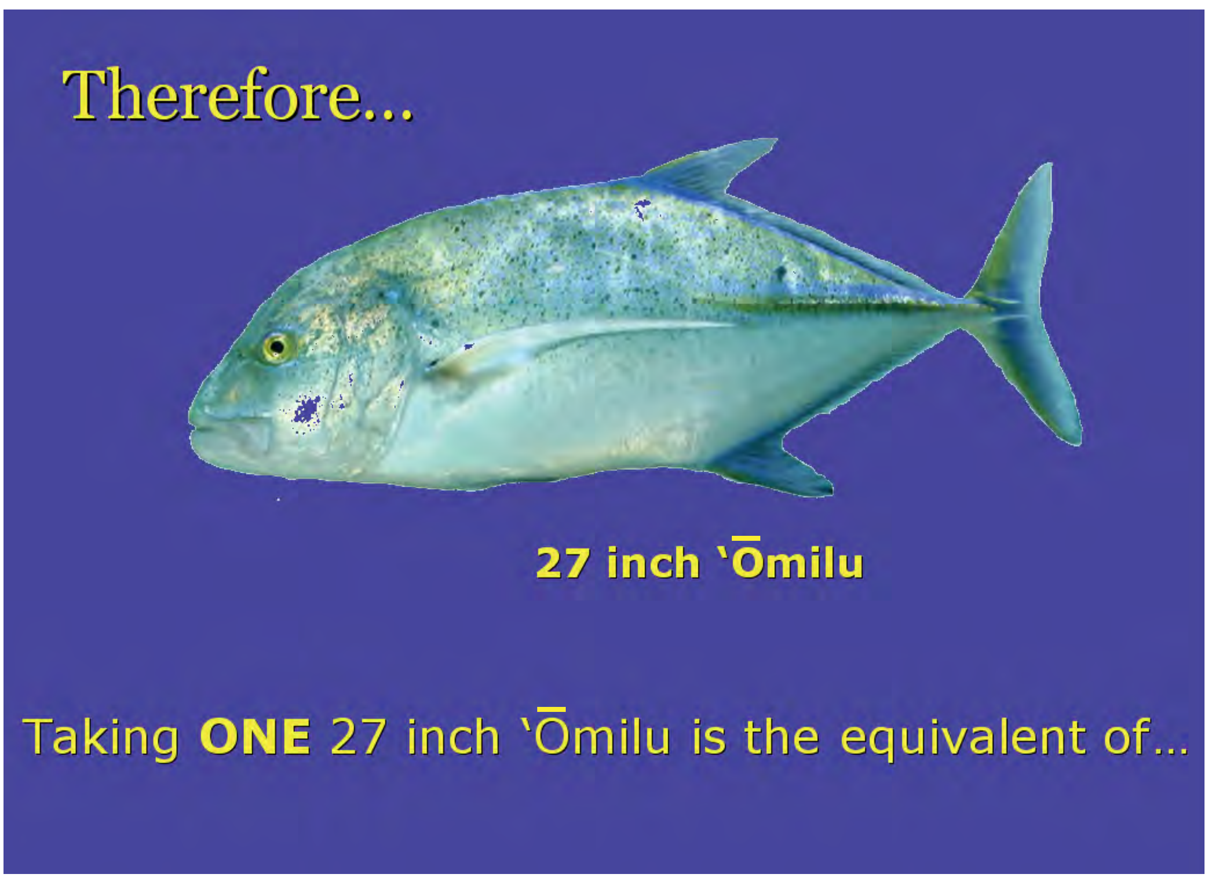

How are they different?
The size of the circles represent biomass. The colors show differences in apex predators, herbivores and low-level carnivores.
3% Apex Predators
48% Herbivores
49% Low-level Carnivores
54% Apex Predators
18% Low-level Carnivores
27% Herbivores
Main Hawaiian Islands (MHI)
Northwestern Hawaiian Islands (NWHI)
Maragos and Gulko 2000

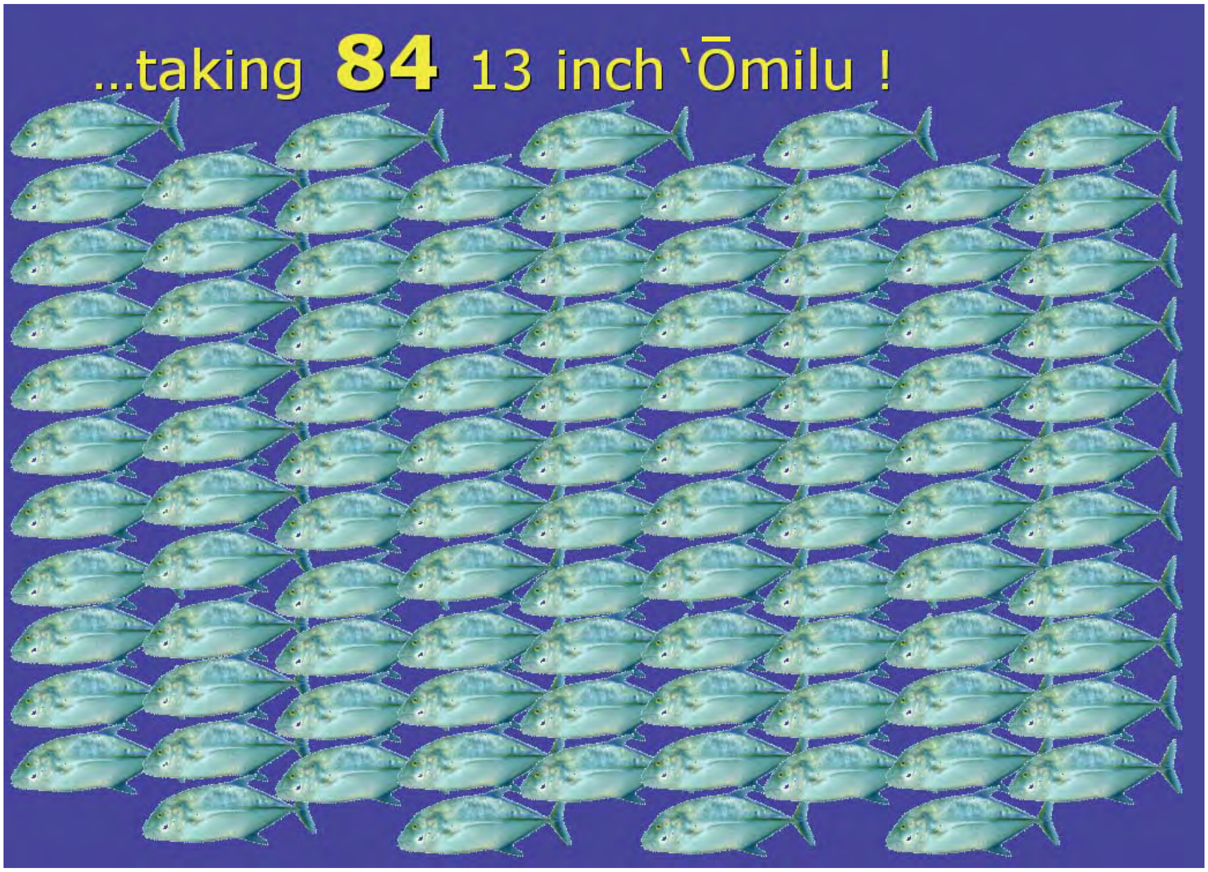

MHI or NWHI?


NWHI or MHI?
NWHI or MHI?


Why such a big difference?
We can get one clue by looking at the number of babies that the ʻŌmilu has at different ages.
ʻŌmilu


How many eggs?
• The 13-inch ʻŌmilu produces about 50,000 eggs.
13 inch ʻŌmilu
•Produces ~ 4 million eggs or 84 times more eggs than a 13” ʻŌmilu!
27 inch ʻŌmilu


Therefore...
27 inch ʻŌmilu
Taking ONE 27 inch ʻŌmilu is the equivalent of...



How will we mālama our reefs so that they will be healthy for future generations?

Human Impact

Photo by Polynesian Voyaging Society

Nānā ka maka; hana ka lima.

Observe with the eyes; work with the hands.
Just watching isn't enough. Pitch in and help!
— Mary Kawena Pukui, `Ōlelo No`eau #2267

Human Impact

How is it that so much `ōpala (rubbish) has made its way onto our beaches and into the sea? Are we destined to live with multi-colored sand beaches sprinkled with the broken down plastic bits of our disposable consumerism? What has led to this staggering volume of discarded nets, lines, and plastic trash that takes such a devastating toll on our reefs and marine life? Something is desperately wrong. It is our kuleana (responsibility) to pitch in and help.

Source of Marine Debris

Marine debris originates on land and at sea. Land-based human debris is rubbish that is blown or washed into the ocean from beach litter, landfills, storm drains, streams, and rivers. These land-based activities contributed most of the debris found in the 2002 International Coastal Clean-up conducted by The Ocean Conservancy (TOC, 2002). An analysis of the 8.2 million pounds of debris that were collected in this worldwide effort found over 1 million cigarette butts, 440,000 food wrappers or containers, 220,000 bottles, 32,000 pieces of fishing line, and 8,000 tires (TOC, 2002).

Marine debris that originates at sea comes from commercial fishing and shipping passenger slips, recreational boaters and fishers, and from off-shore oil rigs. In the NWHI, the majority of marine debris comes from the sea. Interestingly, the two most common nets found in the NWHI marine debris (by weight) are trawling nets and monofilament gill nets. Yet these types of fisheries don't occur here (Maragos & Gulko 2002). Where do the nets come from? The islands are situated to trap debris that drifts with the slow-moving North Pacific gyre, which is the current that circles in the North Pacific Ocean. Studies have shown that marine debris in the North Pacific is likely to end up in the convergence zone of the subtropical North Pacific. This zone migrates with the seasons, and in the winter months shifts south to the NWHI where debris accumulates. In El Niño winters, the zone shifts farther south to the main Hawaiian Islands and deposits marine debris on some of our reefs and beaches (Maragos & Gulko 2002).

As the first two instructional activities in this unit illustrate, marine debris is much more than unsightly litter. It causes serious damage to coral reefs as nets and lines drag across coral and marine animals become entangled or ingest debris. Monk seals, turtles, and seabirds that become entangled in the drifting nets and lines may drown, or eventually die of starvation, predation, or infection due to tightening lines on their bodies. Plastic materials that are mistaken as food and ingested by marine animals may accumulate and block their intestines causing death by starvation.

Other Pollutants

A less visible threat to the health of our oceans is water pollution from materials that we apply to the land, wash down our driveways, drain into our wastewater treatment facilities, or release into the air. These include household and industrial hazardous wastes, pesticides and fertilizers, and automotive fluids and gases. These types of pollutants, which enter the ocean from our watersheds, are referred to as non-point source pollutants. They are dispersed in

Between 1996 and 2003, 364 tons of marine debris were removed from the NWHI (NOAA, 2003).

the environment from so many sources that it is difficult to pinpoint where they originate. This brings the issue home to each of us as we consider how our consumer actions and other habits have an impact on the land and sea. Raising awareness about how these substances end up in the ocean and what we can do to pitch in and reduce this pollution is the focus of the third instructional activity in this unit.

Seeking Solutions

Early Hawaiians managed the land and water resources within ahupua`a—land divisions that typically ran from the mountains to the sea. People farming and fishing within the ahupua`a recognized the connection of mountain forests to the coral reefs in the sea. A healthy reef required a healthy forest. Wai (fresh water) was considered sacred. It was essential for all life on land and nutrients from the streams enriched the reef. Returning to a sense of reverence for the environment that sustains us is a critical need as we witness the deterioration of our `āina (land). Realizing the connections between the land and sea and how our actions on land affect the reef, we can learn from the past to mālama (care for) our environment today.

Government and nonprofit agencies are involved in a multi-agency partnership to remove marine debris from the NWHI. In 2003, 16 people worked for 4 months to remove 122 tons of derelict fishing gear from the islands (NOAA, 2003). This kind of cooperation is essential to undertaking such a monumental task. But if each of us looks within the realm of our daily lives, there is much that individuals can do to reduce marine debris and water pollution. Picking up litter, recycling, reducing use of disposable products, opting not to purchase products with excessive packaging, volunteering for stream and beach clean-ups, substituting hazardous chemicals with alternative products, and fertilizing our lawns and gardens organically are all steps we can take to make our island home a healthier place now and for the future.

References

Maragos, J. & Gulko, D. (Eds.). (2002). Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim Results Emphasizing the 2000 Surveys. Honolulu, HI: U.S. Fish and Wildlife Service, and the Hawai`i Department of Land and Natural Resources.

NOAA Fisheries. (2003).Multi-Agency Marine Debris Program Synopsis. Honolulu, HI: Coral Reef Ecosystem Division, Marine Debris Program, Honolulu Laboratory.

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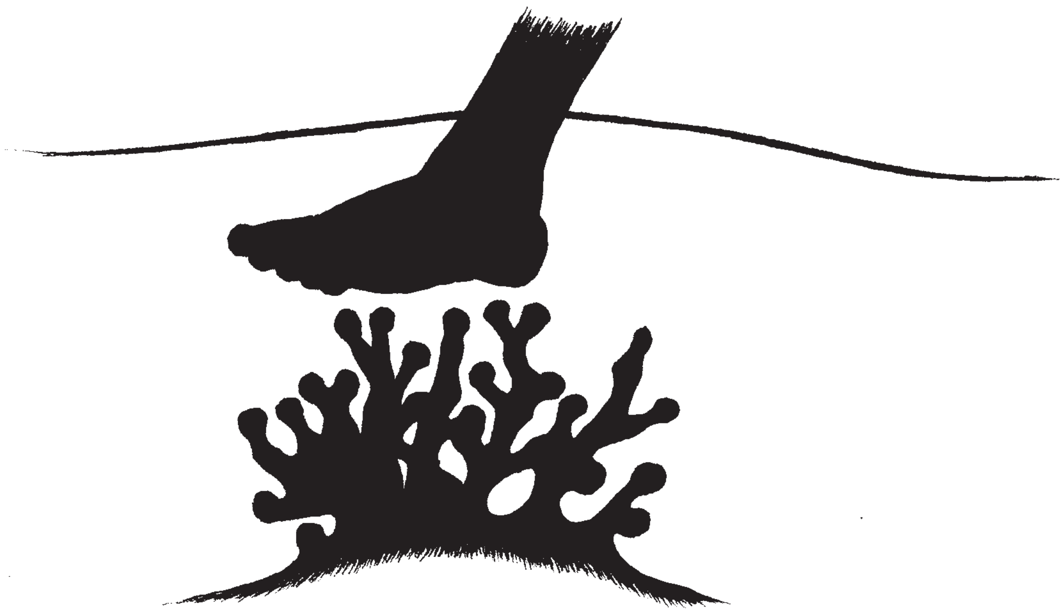
Grades 4 - 5 Unit Overview

Hawai`i DOE Content Standards & Nā Honua Mauli Ola	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Science 2: The Scientific Process: Nature of Science Science, Technology, and Society Unifying Concepts and Themes	How does human debris have a negative impact on marine life, and what can we do to solve this problem? Activity: Singing the `Ōpala Blues	• Marine debris comes from: 1) the land, as rubbish that drifts on air currents and washes into the ocean from storm drains, landfills, and beaches; and 2) the ocean, as fishing lines, nets, and other materials discarded by ships, boaters, and fishers. • Discarded fishing nets and lines damage coral reefs and entangle seabirds, monk seals, turtles, and other marine life. • Discarded plastics can be mistaken for food and limit the amount of digestible material in an animal's stomach, causing death by starvation. • We can help to solve the problem of marine debris by reducing consumption of plastic disposable goods, reusing or recycling the products we do buy, and preventing fishing lines and nets from becoming waste.	4.2.1 Describe how the use of technology has influenced the economy, demography, and environment of Hawai`i. 5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.
Science 1: The Scientific Process: Scientific Investigation Nā Honua Mauli Ola #15 Teach others about the concept of mālama through example. Participate in conservation and recycling practices and activities.	What can we learn from a bolus about seabirds and human impact on seabird habitat? Activity: What's for Dinner?	• Indigestible material found in a bolus regurgitated by a seabird provides clues to human impact on the marine environment. • We can all make a difference by picking up rubbish in our environment and teaching others about the dangers of marine debris.	4.1.1 Describe a testable hypothesis and an experimental procedure. 5.1.2 Formulate and defend conclusions based on evidence.

Science 1: The Scientific Process: Scientific Investigation	How do products we use on land affect our ocean and beaches? How effective are some alternative products that have less impact on the environment? Activity: From the Land to the Sea	• Detergents, oils, paints, and other materials that we wash down our driveways can end up in storm drains and in the ocean. Household cleaners and chemicals that we wash down drains can also end up in the sea from cesspools and overloaded wastewater treatment plants. • Fertilizers and pesticides that we apply to our lawns and gardens can percolate down to groundwater and/or end up in our streams and ocean. • We can prevent these (non-point source) pollutants from entering our environment where they have a negative impact on our health and the health of other species.	4.1.1 Describe a testable hypothesis and an experimental procedure. 5.1.2 Formulate and defend conclusions based on evidence.

Student Journal

Unit 4 – Human Impact



Nānā ka maka; hana ka lima.

Observe with the eyes; work with the hands.
Just watching isn't enough. Pitch in and help!
—Mary Kawena Pukui, `Ōlelo No`eau #2267

Student's Name: ______________________________

School: ______________________________

Date started: ______________________________

Date ended: ______________________________

Student Assessment Overview

Unit Essential Questions

- How does human debris have a negative impact on marine life, and what can we do to solve this problem?
- What can we learn from a bolus about seabirds and human impact on their habitat?
- How do products we use on land affect our ocean and beaches? How effective are some alternative products that have less impact on the environment?

How you will be graded for this unit:

Individual Journal

It is your responsibility (kuleana) to complete a journal for this unit. Following is a checklist of the pages you will need to include in your journal. Place this page in your journal and make a check next to each item when you complete it. You will be given more details during each lesson.

Journal Pages	3Completed
Gr. 4	
Singing the `Opala Blues – Standard: Science 2 • Write a one-page journal entry that describes how the use of plastic materials affects the marine environment, people, and economy of Hawai`i. Include suggestions for reducing plastic waste in the ocean.	
What's for Dinner? – Standard: Science 1 • Write a lab report that follows the steps involved in scientific inquiry (purpose, hypothesis, materials, procedure, results, and conclusion).	
From the Land to the Sea – Standard: Science 1 • List the products in your home that could contribute to water pollution in your community. • Write a lab report describing your research question about an alternative product. Describe your hypothesis, materials, procedures, results, and conclusions.	
Gr. 5	
Singing the `Ōpala Blues – Standard: Science 2 • Develop a model or simulation to show how plastic affects the marine environment. Describe the model or simulation in your journal. • Write a summary of the problem and suggest solutions to reduce plastic waste in the ocean.	
What's for Dinner? – Standard: Science 1 • Write a lab report that follows the steps involved in scientific inquiry (purpose, hypothesis, materials, procedures, results, conclusions). • Formulate and defend conclusions based on evidence gathered.	
From the Land to the Sea – Standard: Science 1 • List the products in your home that could contribute to water pollution in your community. • Write a lab report describing your research question about an alternative product. Describe your hypothesis, materials, procedure, results, and conclusion. Defend your conclusion by showing how it is supported by evidence.	

Culminating Activity – Group Project

As you work on your journal, you will be working toward completing the culminating activity for this unit. Your Challenge: Design and carry out a project to reduce the impact of a household product or lawn and garden product on the marine environment. Work in teams to develop a creative way to mālama (care for) the environment and share what you have learned with other classes in the school. Team projects should include:

- A written report that summarizes your project. The report should include the problem you are trying to solve, the action you took to solve the problem, and your conclusions about how well your project worked.
- A description of how the use of a product has affected the environment, people, and the economy (Gr. 4)
- Visual aids such as photographs, video, or drawings that show your group in action (Gr. 4)
- Models or simulations to demonstrate how your project will reduce the impact of a product on the environment (Gr. 5).

Use the rubric on the following page to guide you as you develop your presentation.

Unit 4 Culminating Activity Rubric - Gr. 4

Rubric for Self Assestment

Team Names________________________________ Student Name________________________________

DOE Benchmarks, GLOs, & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Science 2: The Scientific Process: Nature of Science Science, Technology, and Society Describe how the use of technology has influenced the economy, demography, and environment of Hawai`i. Points ___	Our project clearly explained how the use of a product has affected our environment and suggested ways to conserve the environment. We also explained how the product affects people and the economy.	Our project described how the use of a product has affected our environment. We also described how the product affects people and the economy.	Our project gave examples of how the use of a product has affected our environment. We also gave an example of how the product affects people and the economy.	We recognize that the use of the product we chose affects the environment, people, and the economy. But our project didn't clearly show this.
Nā Honua Mauli Ola #15 – 3 Learners teach others about the concept of mālama through example. Points ___	Our project taught others about ways to mālama the environment and provided excellent examples of taking actions to care for our island.	Our project taught others about a way to take action and mālama the environment.	We had ideas about ways to mālama the environment, but our project didn't clearly explain the ideas.	Our project did not clearly show others about ways to mālama the environment
GLO #5 Effective Communicator Communicates effectively and clearly through speaking, using appropriate forms, conventions, and styles to convey ideas and information for a variety of audiences and purposes Points ___	Our team understood the purpose of our presentation, and organized and presented information very clearly to our audience.	Our team understood the purpose of our presentation, and organized and presented information clearly to our audience.	Our team understood the purpose of our presentation, but we needed to work on organizing our information to communicate more clearly to our audience.	Our team presentation was not clear to the audience because we weren't organized or clear about the purpose of our presentation.
Visual Aids Points ___	The visual aids we used enhanced our project message.	Our visual aids were a good way to teach others.	Our visual aids could have been much better.	We did not use visual aids.

Unit 4 Culminating Activity Rubric - Gr. 5

Rubric for Self Assestment

Team Names_____________________________ Student Name_____________________________

DOE Benchmarks, GLOs, & Nā Honua Mauli Ola	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	\`Ano Mākaukau (Almost at Standard)	Mākaukau \`Ole (Below Standard)
Science 2: The Scientific Process: Nature of Science Unifying Concepts and Themes Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world Points ___	Our team's model or simulation was a very effective way to demonstrate how to reduce the impact of a product on the environment.	Our team's model or simulation was an effective way to demonstrate how to reduce the impact of a product on the environment.	Our team's model or simulation did not clearly demonstrate how to reduce the impact of a product on the environment.	Our team's model or simulation did not demonstrate how to reduce the impact of a product on the environment.
Nā Honua Mauli Ola #15 – 3 Learners teach others about the concept of mālama through example. Points ___	Our team's model or simulation was a very effective way to demonstrate how to reduce the impact of a product on the environment.	Our project taught others about a way to take action and mālama the environment.	We had ideas about ways to mālama the environment, but our project didn't clearly explain the ideas.	Our project did not clearly show others about ways to mālama the environment
GLO #5 Effective Communicator Communicates effectively and clearly through speaking, using appropriate forms, conventions, and styles to convey ideas and information for a variety of audiences and purposes Points ___	Our team understood the purpose of our presentation, and organized and presented information very clearly to our audience.	Our team understood the purpose of our presentation, and organized and presented information clearly to our audience.	Our team understood the purpose of our presentation, but we needed to work on organizing our information to communicate more clearly to our audience.	Our team presentation was not clear to the audience because we weren't organized or clear about the purpose of our presentation.

Singing the `Ōpala Blues

Essential Question: How does human debris have a negative impact on marine life and what can we do to solve this problem?

Hawai`i DOE Content Standard

Science 2: The Scientific Process: Nature of Science – Science, Technology, and Society; Unifying Concepts and Themes

- Understand that science, technology, and society are interrelated.

Grades 4 - 5 Benchmarks

4.2.1 Describe how the use of technology has influenced the economy, demography, and environment of Hawai`i.

5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Nā Honua Mauli Ola #15

Engage in experiences that mālama the entire learning community and the environment to support learning and good practices of stewardship, resource sustainability, and spirituality.

- Learners participate in conservation and recycling practices and activities.

Key Concepts

- Marine debris comes from: 1) the land as rubbish that drifts on air currents and washes into the ocean from storm drains, landfills, and beaches; and 2) the ocean as fishing lines, nets, and other materials discarded by ships, boaters, and fishers.
- Discarded fishing nets and lines damage coral reefs and entangle seabirds, monk seals, turtles, and other marine life.
- Discarded plastics can be mistaken for food and limit the amount of digestible material in an animal's stomach, causing death by starvation.
- We can help to solve the problem of marine debris by reducing consumption of plastic disposable goods, reusing or recycling the products we do buy, and preventing fishing lines, nets, and other plastics from becoming waste in the ocean.

Activity at a Glance

Students participate in an entanglement demonstration and play a marine debris game. They summarize what they have learned in their journals and Gr. 5 students develop models or simulations.

Time

3 – 4 class periods

Assessment

Students:

- Write a one-page journal entry that describes how the use of plastic materials affects the marine environment, people, and economy of Hawai`i. Include suggestions for reducing plastic waste in the ocean. (Gr. 4)

- Develop a model or simulation to show how plastic affects the marine environment. Write a summary of the model or simulation and suggest solutions to reduce plastic waste in the ocean. (Gr. 5)
- Report to the class on their plastic consumption and how they implemented recycling and conservation practices.

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Explain how the use of technology has influenced the economy, demography, and environment of Hawai`i and suggest ways to conserve the environment.	Describe how the use of technology has influenced the economy, demography, and environment of Hawai`i.	Give examples of how the use of technology has influenced the economy, demography, and environment of Hawai`i.	Recognize that the use of technology has influenced the economy, demography, and environment of Hawai`i.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world.	Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.	With assistance, use models or simulations to represent features of objects, events, or processes in the real world.	Recognize examples of models or simulations that can be used to represent features of objects, events, or processes.

Vocabulary

biodegradable – capable of being broken down by the action of microorganisms
non-biodegradable – not capable of being broken down by the action of microorganisms
marine debris – human-made solid material that is dumped or washed into the marine environment
`ōpala – rubbish, trash

Materials

- student journal and assessment pages (provided in Unit Overview)
- photo CD (provided)
- game cards (provided in Unit 2, Land to Sea Survival Shuffle activity)
- 6 clipboards
- box of rubber bands
- colored stickers (three different colors to represent different kinds of marine debris)
- samples of marine debris (pieces of plastic, disposable lighter, styrofoam popcorn, plastic six-pack rings, fishing net, and fishing lines)
- samples of biodegradable materials (cardboard, paper, banana peels)

Advance Preparation

Use the game cards from the Land to Sea Survival Shuffle activity in Unit 2 (see Preparation on page 85). In addition, prepare five more pages of food cards for each type of animal. Attach different color stickers to one-fourth of the food cards to represent marine debris. For example, blue = plastic lighters, red = food wrapper, yellow = fishing line. Gather samples of marine debris and biodegradable items to display in the classroom. Also make a copy of the student journal and assessment pages from the Unit Overview for each student.

Background Information

A walk down the aisle of a supermarket or discount retailer reveals the vast array of plastic packaging and disposable plastic containers and products that are so prevalent in our society. In 1986, the U.S. produced six billion tons of disposable plastic packaging (Pacific Whale Foundation, 2004). A stroll along the beach reveals where too much of those plastics end up—in our marine environment. Since plastics are non-biodegradable, they persist in the environment for centuries. While wave action may cause the plastics to break into smaller and smaller pieces, even these small bits can accumulate in the intestines of seabirds.

Each year, millions of sea turtles, marine mammals, and seabirds ingest plastics that are mistaken as food or become entangled in marine debris (EPA, 2004). Plastic harms marine animals in a number of ways. They become entangled in discarded fishing lines, nets, and six-pack rings, or develop infections from the tightening material. Plastics that are mistaken for food clog the animals' intestines and may lead to death by starvation. In addition, toxic substances in marine debris may disrupt reproduction in marine animals or cause death.

Hawaiian Monk Seals

Marine debris is very hazardous for the endangered Hawaiian monk seal. Nets can entangle the seals and they may drown before they can free themselves. The Northwestern Hawaiian Islands provide primary habitat for monk seal birthing and weaning, and each year seals, particularly weaned pups, are found entangled in nets and lines.

Seabirds

Seabirds become entangled in disposed nets, gear, and plastic trash such as soda rings. They also ingest disposable cigarette lighters and other small plastics.

Green Sea Turtles

When they are active, Hawaiian green sea turtles must swim to the ocean surface to breathe every few minutes. When they are resting, they can remain underwater for as long as two and one half hours without breathing. Turtles that become entangled and pulled down by nets struggle to get free and need to surface for air. Marine debris, like nets, cigarette lighters, plastic bags, and ballpoint pens can clog their digestive system and cause turtles to starve to death. Sea turtles may mistake discarded balloons as food, which can then block their airways and cause death by suffocation.

See Unit 2, "Land to Sea Survival Shuffle," for more information on the feeding behaviors of the animals featured in this instructional activity.

Teaching Suggestions

Introducing the Unit:
Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.

1. Have students imagine that they are turtles swimming through the water and that their hands are turtle flippers. Give each student a rubber band. Ask students to place the rubber band around the pinky finger, across the back of the hand, and around the thumb.
2. Explain that the rubber band is discarded fishing net that is pulling the turtle under water. Note that while the turtle is active, it must come to the surface every few minutes to breathe. So challenge the "turtles" to hold their breath while trying to remove the "net" without the use of their other "flipper."
3. Discuss student reactions to this demonstration. How difficult was it to remove the "net"? How would a turtle become untangled in a net?
4. Show the images of marine debris on the photo CD provided and discuss the types of `ōpala (trash) and materials that are entangling marine life—abandoned nets, fishing line, and six-pack rings.

5. Form six teams—two each of seabirds, turtles, and monk seals. Distribute the animal cards for students to wear around their necks. Appoint a recorder for each team and give those students a clipboard. Ask them to collect their team's food cards at the end of each round of the game and place the cards on the clipboard. Teams should give themselves a name and place the name on the clipboard to identify it.
6. Go outside to a cleared grassy area and play the game. See game instructions provided at the end of this activity. Note that this is a modified version of the Land to Sea Survival Shuffle in Unit 2. This game focuses on marine debris, but the players (just like the marine animals) don't know the marine debris is in the water.
7. After playing the game, have teams return to the classroom and count the number of food cards they retrieved. Ask students to count the number of cards they had with each color of sticker. Debrief and explain what each of those colors represents. Ask teams to report on their marine debris count and record these totals on the board.
8. Have teams subtract the number of cards with marine debris from their total food count. Ask for their totals and record these on the board. Teams must have at least three food cards without marine debris for each animal on the team in order to survive. The team with the "healthiest" animals (those with the most food) is the winner!

9. Discuss how not knowing which foods had marine debris mimics the feeding activity of these animals. (They don't know they are consuming plastic or other marine debris.)

10. Display the biodegradable materials you collected earlier along with the plastic items that are often found as marine debris in the ocean. Lead a general discussion about how the technology that led to the development and use of plastics has affected the environment, people, and the economy.

    - What material is used to manufacture plastic? (It is manufactured from fossil fuels.)
    - How does the use of plastics affect people? (Lightweight materials are used in medical devices, computers, food containers, etc. Disposable plastics are convenient for consumers.)
    - How does the use of plastics affect the economy? (Jobs are created to manufacture and recycle plastics. Many plastic items are inexpensive for consumers. Lightweight materials used in vehicles can lower fuel consumption, etc.)
    - How does the use of plastics affect the ocean environment? (Marine debris entangles wildlife and plastics are ingested by animals, which can lead to their death.)
    - How do plastics and other forms of pollution get into the ocean?
    - How is the plastic marine debris different from the biodegradable materials?
    - What do the three "Rs" (Reduce, Reuse, Recycle) of pollution control mean?

11. Challenge students to keep track of all of the disposable plastic items, including packaging on products, they use during one full day. Have them list each item and make note of what they do with it when they are finished using the product.

12. Ask students to share with their classmates and describe how they disposed of plastics, including ways that they reduced (used alternative products), reused, or recycled.

13. Have students complete the assessment activities by recording in their journals. Challenge Gr. 5 students to develop models or simulations that show how plastic affects the marine environment, e.g., simulate how animals can become entangled in debris, or develop a model that shows how plastics from land can be washed into the ocean.

Extended Activity

Go outside and collect rubbish around the school and/or empty the rubbish can in the classroom. Sort the trash into piles (plastic, paper, rubber, metal, etc). Ask students to identify which items would most likely end up at the ocean and become marine debris. Which items float and which are blown in the wind? Place items in a bucket of water to see which float. How could the various items affect marine life? Could they become entangled in it? Could they swallow it? Which items could be recycled?

References

Pacific Whale Foundation. (2004). Marine Debris Fact Sheet. Retrieved 7-13-04 from http://www.pacificwhale.org/childrens/fsdebris.html

U.S. Environmental Protection Agency. (2004). Marine Debris Abatement. Retrieved 7-13-04 from htpp://www.epa.gov/owow/oceans/debris

Other Sources of Information

The Ocean Conservancy. (2003). Marine Debris. http://www.oceanconservancy.org/dynamic/learn/issues/debris/debris.html

PEW Oceans Commission. (n.d.) Marine Pollution. Retrieved 7-14-04 from http://www.pewoceans.org/inquiry/marine

Kamehameha Schools has posted information about the impact of marine debris, particularly cigarette lighters, on the birds of Midway. http://kms.kapalama.ksbe.edu/projects/2003/albatross/

Objective:

To find enough food for survival*

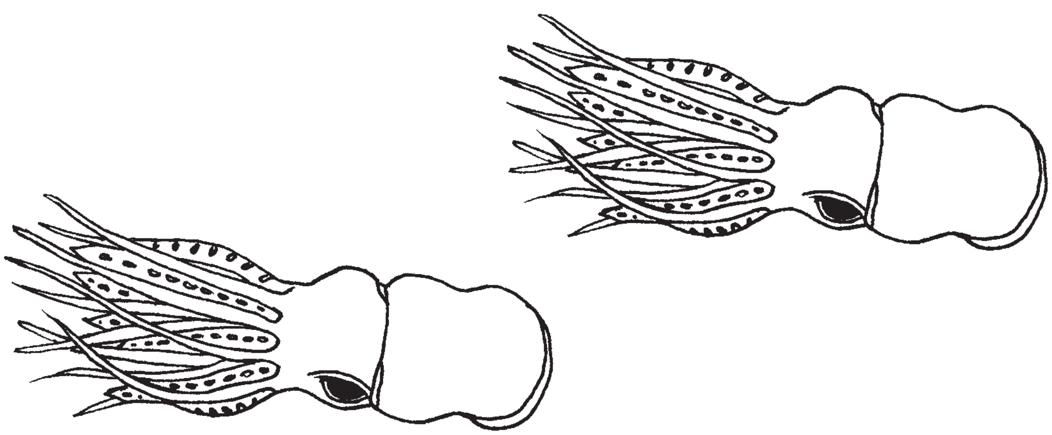
Game Set-up:

- Animal food cards are distributed randomly and widely around the playing area.
- Six teams of students (two each of monk seals, green sea turtles, and seabirds) wear identifying tags around their necks and search for food that is the same color as their tags.

To Play:

- At the signal, teams begin searching for food and collecting food cards.
- After 30 seconds, the teacher calls time. At that time, each team clips its food cards together and places them on a clipboard.
- Continue playing for two more 30-second rounds or until all food cards are gone.
- At the end of the third round, students collect all remaining cards from the playing area and hand them to the teacher.
- Return to the classroom and debrief.

* Students should play the game without knowing what the stickers on the food cards represent. These cards will be subtracted from their total food count. The winning team will be the one with the most food that does not have marine debris.



What's for Dinner?

Essential Question: From a bolus, what can we learn about seabirds and human impact on their habitat?

Hawai`i DOE Content Standard

Science 1: The Scientific Process: Scientific Investigation

- Discover, invent, and investigate using the skills necessary to engage in the scientific process.

Grades 4 - 5 Benchmarks

4.1.1 Describe a testable hypothesis and an experimental procedure.

5.1.2 Formulate and defend conclusions based on evidence.

Nā Honua Mauli Ola #15 - 3

Engage in experiences which mālama the entire learning community and the environment to support learning and good practices of stewardship, resource sustainability, and spirituality.

- Learners teach others about the concept of mālama through example.

Key Concepts

- Indigestible material found in a bolus regurgitated by a seabird provides clues to human impact on the marine environment.
- We can all make a difference by picking up rubbish in our environment and teaching others about the dangers of marine debris.

Activity at a Glance

Groups of students collaborate to dissect an albatross bolus and discover what it reveals about human impact on the seabird's habitat. Students write a laboratory report, and create a display of items found in their boluses. They share their findings and their displays with others in the school.

Time

2 - 4 class periods (Plan for a double period to dissect the boluses.)

Assessment

Students:

- Write a laboratory report that follows the steps involved in scientific inquiry (purpose, hypothesis, materials, procedures, results, conclusions).
- Formulate and defend conclusions based on evidence gathered (Gr. 5).
- Create a display of items found in the bolus and share that display with others in the school.

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Create a testable hypothesis and an experimental procedure to test it.	Describe a testable hypothesis and an experimental procedure.	Identify, with assistance, a testable hypothesis and an experimental procedure.	Recognize, with assistance, a testable hypothesis or an experimental procedure.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Formulate and defend conclusions that are supported by detailed evidence and make connections to the real world.	Formulate and defend conclusions that are supported by evidence.	Make conclusions that are partially supported by evidence.	Make conclusions without evidence.

Vocabulary

bolus – fat, cigar-shaped mass that is regurgitated by some types of seabirds and contains indigestible materials (e.g. plastics, squid beaks)
foraging ground – place from which an animal gets its food
indigestible – digestible with difficulty or impossible to digest
purpose – goal
hypothesis – educated guess
procedures – sequence of actions used in an experiment
results – outcomes, what happened
conclusions – general statements about findings
marine debris – human-made solid material that is dumped or washed into the marine environment

Materials

- lab report sheet (provided)
- marine debris fact sheet (provided)
- bolus (see Advance Preparation)
- Navigating Change video segment "Human Impact" (provided)
- photograph of Laysan Albatross (provided on photo CD)
- shallow boxes or styrofoam trays (one per group of four students and one for sample)
- acetate sheets (one per group and one for sample)
- glue, tape, and push pins
- rulers, pencils, and colored pens
- paper
- scissors
- tweezers or chopsticks (one or two per group)
- surgical gloves (one set per group of four)
- face masks (optional: one per student)
- goggles (one pair per group)
- soda case boxes (optional: to use for dissecting the bolus)
- paper towels and old newspaper

Advance Preparation

Order boluses by calling Ann Bell, U.S. Fish and Wildlife Service, 300 Ala Moana Blvd., Room 5-311, Honolulu, HI 96850. Telephone: 808-792-9532, or e-mail at Ann_Bell@fws.gov.

Gather enough shallow boxes or styrofoam trays to have one per group of four students. Cut a sheet of light-colored paper to fit inside each box. Cut pieces of acetate to fit over the box or tray to create a display model. Make a sample display box to show students. Place a couple of small objects in the box and secure them with glue, tape, or push pins. Number the items. Tape the acetate over the box. Glue a piece of paper on the side of the box that identifies each object by number.

Be prepared to air out the room during the activity and after it. Allow enough time for clean up. This activity is highly engaging but it does create a mess!

Background Information

Laysan albatross eat squid, fish, fish eggs, and crustaceans. They sit on the surface of the water and pick up their prey with their sharp, hooked beaks. Adult albatross return to land to feed their chicks by regurgitating their stomach contents. They feed their fast-growing chicks regurgitated squid, flying fish eggs, and fish larva. Juvenile albatross chicks regurgitate indigestible material in a fat, cigar-shaped mass that is called a bolus. When we dissect a bolus, we find clues to the health of the foraging ground where thousands of albatross gather food for their hungry chicks. Boluses often contain squid beaks, small bits of pumice, wood, and a soft, string-like substance that keeps flying-fish egg masses intact.

Unfortunately, boluses also often contain plenty of unnatural materials. The U.S. Fish and Wildlife Service employees find boluses laced with plastics by the hundreds in the NWHI. Some of those plastics come from thousands of miles away. The albatross adults ingest the plastics along with flying fish eggs. Flying fish attach their eggs to floating materials in the ocean; these materials used to be all natural, such as wood or pumice, but within the last 20 years, more and more of these floating materials are plastics. When the albatross scoop up the eggs they scoop up the plastics as well. The concentration of plastics in the boluses is representative of a large number of plastics floating in the ocean, and plastics that have displaced natural substances as anchoring substrate for flying fish eggs. Adult albatross have the ability to purge these consumed plastics by throwing them up, but the chicks have to reach a certain size, or age, before they are able to throw up a bolus. If the chicks consume too many plastics before they are able to throw them up, then they are in danger of dehydration or starvation. It is not uncommon to come upon an albatross chick carcass containing intact toothbrushes, plastic toys, bottle caps, cigarette lighters, and fishing line. Some albatross chicks that are presumed dead from plastics can have as much as 400 grams of plastic in their stomachs.

People can only confirm that a particular seabird produces a bolus when they see the evidence in the birds' nesting colony. In the world's largest Laysan albatross colony on Midway Atoll National Wildlife Refuge, thousands of boluses are scattered around the landscape in June near the albatross, which will soon fledge. Other types of seabirds may produce boluses; however, biologists have not noted such except for the bone and feather-laced boluses produced by `iwa (great frigate birds). Since seabirds spend the majority of their time at sea, they may be producing boluses and depositing the evidence at sea.

Seabirds have become a good ecological indicator as to the health of our oceans because they are visible, especially when thousands come to nest on land. However, recent evidence shows that even the smallest sea creatures at the base of the food chain ingest minute particles of broken-down plastic.

Teaching Suggestions

1. Show the Navigating Change video segment, "Human Impact," and discuss students' reactions to it.

2. Show the photographs on the Photo CD of the Laysan albatross and juvenile albatross next to a bolus. Discuss a few of the physical characteristics of this seabird—webbed feet for paddling and "running" on the water's surface to become airborne, a sharp, hooked beak to catch prey, and a tube on the top of the beak from which salt is extruded/shaken. Ask students what they think the bird eats and how it feeds its chicks.

3. Hold up a bolus and provide students with some clues to help them discover what it is and what they might learn by studying it.
   Clues:
   - This is a natural object that comes from juvenile albatross chicks in the NWHI. What do you think it is?
   - What do albatross chicks eat? (squid, flying fish eggs and fish larva regurgitated by their parents)
   - What do the chicks do with the hard, indigestible parts in their food, such as squid beaks? (throw them up in a bolus)
   - What could we learn about the albatross and its habitat by taking apart the bolus and studying it?
   - Scientists are concerned about how plastic rubbish in the ocean affects marine life. Do you think the bolus could provide us with information about plastics in the ocean habitat? How?

4. Distribute the lab report sheets and review the scientific method with students. Ask each student to record a research question and a hypothesis regarding what will be found in the bolus.

5. Form investigative teams of four students. Make sure that each team has at least one student who won't mind dissecting the bolus (although by the end of the class, most students will want to have a chance to do this). Give each team a shallow box or tray and the materials it needs to dissect the bolus. Explain that the boluses have a strong smell, and distribute masks for those who want to wear them.

6. Review preparation and safety measures that should be followed for handling a bolus as noted on information sent with the boluses.
   - Wear protective gloves.
   - Place the bolus on a paper towel or newspaper.
   - Place found items in a closed box.
   - Discard the remaining bolus in the garbage.

7. Give each group a bolus to dissect and ask students to work together to complete the group tasks.
   Group tasks
   - Dissect the bolus.
   - Arrange the items found in the bolus in the display box and identify each item found using a piece of paper on the side of the box.
   - Write the laboratory report.
   - Present findings and conclusions to the class.

8. Invite another class to listen to groups make their presentations. Discuss the findings and conclusions. What do the boluses reveal about human impact on the albatross? What should we do to reduce that impact?

9. To spread the word about marine debris, have students' displays placed in a central location, such as the library in the school. Distribute the marine debris fact sheet and ask students to take it home and share it with their families.

10. Ask students to complete their lab reports with their findings and conclusions.

Extended Activities

Have students investigate the currents in the Pacific, especially those that lead to the deposit of so much debris in the NWHI. For more information on currents, see the following web site for a map detailing ocean currents in the Pacific: http://www.pmel.noaa.gov/np/pages/seas/npmap4.html.

Encourage students to write letters to the editor of the local newspaper to share their concerns about marine debris with others.

Visit the Albatross Project web site at www.wfu.edu/albatross and conduct one of the educational activities described on the site. The activity, "Walk a Mile in Albatross Shoes," is summarized below:

Measure a distance of one mile around the school. Ask students to pick up trash they see along this one-mile area. During the walk, have students think about how much more trash the albatross might find over its long journey. Bring the trash back to the classroom and weigh it. Add all of the measurements together to figure out the total weight of trash that was collected. Albatross chicks that are presumed dead from plastics can have as much as 400 grams of plastic in their stomachs. Figure out how many chicks your class possibly saved by picking up that much trash. Students could also categorize the rubbish (paper, plastics, aluminum, glass, etc.) and graph it by weight found in each category.

To include other birds and wildlife in your discussion, have each student pick a color of trash that they will pick up exclusively. This illustrates the fact that every type of wildlife has specific tastes and will choose certain types of foods. This means that some species are more likely than others to pick up plastics but might be more vulnerable to other hazards.

Have students select one of the following journal prompts and write a paper or poem for extra credit:

- I can help reduce plastic marine debris by…
- As an albatross chick, I would like to send this message to humans…
- It is our kuleana (responsibility) to mālama (care for) the environment because…

Reference

Wake Forest University. (1999). Walk a Mile in Albatross Shoes. Retrieved July 27, 2004 from http://www.wfu.edu/albatross/activity/walk.htm. The Albatross Project. Other excellent reference material including foraging maps from a recent tracking project are also located on this site.

What's for Dinner? Student Lab Sheet

Name ______________________ Date ______________________

Research Question (What is the question you want to answer with this study?)

Hypothesis (Write a complete sentence describing what you think you will find.)

Method (How did you study the bolus?)

Findings (What was in the bolus?)

Conclusion (What do your findings tell you about the albatross and its habitat?)

Did your findings support your hypothesis? Explain.

What do you recommend we do to mālama (care for) the albatross and other species that share its environment?

Debris litters the windward shores of Laysan Island. At any given time only about 50 people live in the Northwestern Hawaiian Islands, yet these uninhabited islands and shallow reefs are littered with debris, plastics and nets that have traveled thousands of miles to get here. Even the most remote places on Earth feel the impacts from human industry, and careless disposal of trash. Copyright David Liittschwager and Susan Middleton

The body of a fledgling Laysan albatross nicknamed "Shed Bird" who died just before this picture was taken. To determine the cause of death Cynthia Vanderlip, manager of the State of Hawaii's Kure Atoll Wildlife Sanctuary, cut the dead bird open to reveal a stomach full of plastics. Copyright David Liittschwager and Susan Middleton

Plastic pieces found in Shed Bird's stomach. All the items in this picture came from one bird. Plastic lighters, bottle caps, and other plastics that are carelessly discarded float in the ocean where they are occasionally consumed by albatross' foraging for food; these plastics are then fed to their young. Copyright David Liittschwager and Susan Middleton

The following page was excerpted with permission from Archipelago: Portraits of Life in the World's Most Remote Island Sanctuary (Hardcover), pp. 212-213, by David Liittschwager, Susan Middleton

A study at Midway Atoll in the mid-1990s attempted to determine the effect of plastics ingestion on Layson albatross chick mortality. Research showed that approximately 75 percent of the chicks examined had up to ten grams of plastic in their proventriculi—part of the birds' complicated stomach system. One chick had ingested 140 grams. Still, the study concluded that "ingested plastic probably does not cause significant direct mortality in Layson albatross chicks."

What we observed a decade later on Kure, Midway's closest neighbor, suggests another story. The contents of Shed Bird's proventriculus weighed 340 grams, more than 80 percent of this was plastic. Imagine: Three plastic bottle caps weigh approximately 5 grams, and a regulation baseball weights about 140 grams—two baseballs' worth of plastic in Shed Bird's stomach!

An albatross chick's proventriculus is designed to hold huge amounts of food, as there may be many days between meals while the parents are out foraging. Chicks eat whatever their parents feed them, plastic included; if these items accumulate in their proventriculi, they will feel full and may not beg properly. Albatrosses eat indigestible items that exist in nature, like squid beaks, and a well-fed chick will have a proventriculus full of these items, which it eventually throws up as a bolus at about the time it's ready to fledge. A normal bolus is about five inches long and two inches wide. Shed Bird had six times that amount of material, most of it plastic, in his proventriculus.

After the death of Shed Bird, I found and examined 60 Laysan albatross chick carcasses on Kure Atoll. Most to them contained more than 200 grams of plastic, with only five chicks registering ten grams or less. These chicks appeared to have succeeded in throwing up their boluses, as nothing—not even squid beaks—was present in their proventriculi. I observed this same phenomenon on Pearl and Hermes Atoll and Laysan Island. Plastic is invading the habitats where parent albatrosses forage. Albatrosses feed where currents come together, and the currents that concentrate food at the surface simultaneously bring in plastic as well.

Inside dead chicks, I found, to my disgust, a printer cartridge, shotgun shell casings, paint brushes, pump spray nozzles, toothpaste tube caps, clothespins, buckles, toys, and shards from larger plastic items such as laundry baskets and buckets. If a bucket ends up on a beach, or a bottle ends up in a river, or a lighter is discarded into a lake, it may eventually wash out to sea, joining the plastic dumped from ships. Over time plastic becomes brittle in sunlight and breaks into smaller and smaller chards. For every pound of naturally occurring zooplankton in the North Pacific's subtropical gyre, there are six pounds of plastic. This debris affects not only the health of Laysan albatrosses but the well-being of the entire world. –David Liittschwager

During a one-day beach clean-up in Hawai`i people picked up 16 tons of rubbish from 82 miles of beach. This weighs as much as 12 Volkswagen Beetles!

Albatross feeding at sea scoop up plastics along with their food and then regurgitate them to their waiting chicks. The plastics can fill the bird's stomach and cause death by starvation.

From 1982 to 2003, 238 Hawaiian monk seals were found entangled in nets and lines in the NWHI. Most were pups that were freed; however, eight seals were found dead. No one knows how many other animals became entangled and drowned.

Plastic debris on our beaches and in the ocean can last a very long time. Did you know that it takes a plastic water bottle 450 years to decompose? Recycle it!

Nylon fishing lines and nets can take up to 600 years to decompose. "Ghost-nets" can continue to float through the ocean and trap and kill marine life for years.

A floating plastic bag or balloon can look like a jellyfish meal to a sea turtle. When they eat these plastics, they can suffocate or starve.

Between 1996 and 2003, 364 tons of marine debris was removed from the "kūpuna" islands. This is as heavy as 73 elephants!

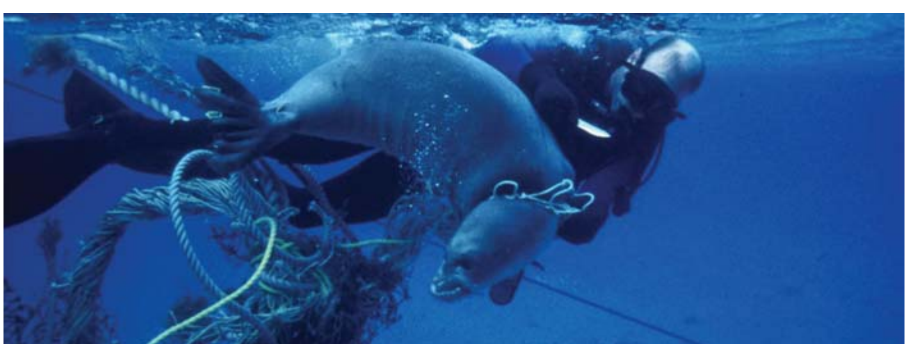
Each year, millions of sea turtles, marine mammals, and seabirds ingest plastics that are mistaken as food or become entangled in marine debris. It doesn't have to be this way! Each one of us can help to solve the problem of marine debris!

How does our plastic debris end up in the stomach of an albatross?

Photo by Robert Shallenberger/ USFWS

What Can You Do?

- Reduce the amount of disposable plastic products you use.
- Pick up litter.
- Reuse and recycle.
- Volunteer for beach and stream clean-ups.
- Teach others about marine debris.
- Let others know why you should not intentionally release any type of balloon outside.



Leaving fishing nets and lines in the ocean is very harmful to wildlife.

Sources:

- http://www.pacificwhale.org/childrens/fsdebris.html
- http://www.oceanconservancy.org/dynamic/learn/issues/debris/debris.htm
- http://www.epa.gov/owow/oceans/debris/

From the Land to the Sea

Essential Questions: How do products we use on land affect our ocean and beaches? How effective are some alternative products that have less impact on the environment?

Hawai`i DOE Content Standard

Science 1: The Scientific Process: Scientific Investigation

Discover, invent, and investigate using the skills necessary to engage in the scientific process.

Grades 4 - 5 Benchmarks

4.1.1 Describe a testable hypothesis and an experimental procedure.

5.1.2 Formulate and defend conclusions based on evidence.

Key Concepts

- Detergents, oils, paints, and other materials that we wash down our driveways can end up in storm drains and in the ocean. Household cleaners and chemicals that we wash down drains can also end up in the sea from cesspools and overloaded wastewater treatment plants.
- Fertilizers and pesticides that we apply to our lawns and gardens can percolate down to groundwater and/or end up in our streams and ocean.
- We can prevent these (non-point source) pollutants from entering our environment where they have a negative impact on our health and the health of other species.

Activity at a Glance

Students conduct a survey of their household products that could contribute to water pollution and test the effectiveness of alternative products that have less impact on the environment.

Time

2 - 3 class periods

Assessment

Students:

- Complete an analysis of products in their homes that could contribute to water pollution in their community.
- Select an alternative product, develop a hypothesis, test its effectiveness, and make recommendations.
- Write a lab report describing their research question, hypothesis, procedure, results, and conclusion.

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Create a testable hypothesis and an experimental procedure to test it.	Describe a testable hypothesis and an experimental procedure.	Identify, with assistance, a testable hypothesis and an experimental procedure.	Recognize, with assistance, a testable hypothesis or an experimental procedure.

Gr. 5

Advanced	Proficient	Partially Proficient	Novice
Formulate and defend conclusions that are supported by detailed evidence and make connections to the real world.	Formulate and defend conclusions that are supported by evidence.	Make conclusions that are partially supported by evidence.	Make conclusions without evidence.

Vocabulary

alternatives – one of two or more choices
fertilizers – substances (natural or chemical) that supply nutrients to the soil
hazardous – potentially harmful
mālama `āina – care for the land
pesticides – substances used to control pests

Materials

- take-home sheet (provided)
- some common household cleaning products and garden products
- healthy alternative products (see take-home sheet)
- mixing bowls
- measuring cups and spoons
- gloves and safety goggles
- spray bottles
- sponges

Advance Preparation

Make a copy of the take-home sheet for each student. Gather some of the products listed on the sheet for class discussion.

Background Information

What's under your sink or in your shed that could pose a hazard to your health or the environment? Chances are that there are a variety of chemicals lurking in these hidden places, many of which need to be "disposed" of. Do we dilute, flush, drain, stuff, trash, or stash them? It's a dilemma that all conscientious consumers confront as we deal with the consequences of our consumerism.

When we follow the potential pathways that materials can take if they are flushed or washed down our drains or washed down our driveways, it's clear that there is no "away." Our drains lead to wastewater treatment plants that use only primary treatment to remove solids. The effluent is then released several miles from shore. Honolulu's Sand Island treatment plant is one of the few facilities in the U.S. where the Environmental Protection Agency (EPA) allows only primary treatment of waste. The effluent from this facility is noted by the EPA as among the most polluted in the country (Moriwake, 2004). When there are heavy rains, our wastewater treatment plants can be overwhelmed, causing raw sewage, pesticides, and other wastes to run off directly into nearshore waters.

Our storm drains carry materials from streets and driveways directly into streams and down to the ocean. This pathway provides a direct link from our homes to the sea. Materials that we release into our yards can either run off into streams or percolate down to groundwater. It is vital that we recognize these connections and think carefully about our actions. It is best to read labels and follow directions for safe disposal. Many household cleaners can be flushed down the drain with plenty of water. Paintbrushes should be cleaned in a sink with plenty of water instead of in the yard. Used paint and oil can be disposed of in the rubbish, but should be allowed to dry out or be absorbed with rags or newspaper before disposing. Flammable materials like gasoline, or hazardous materials like pesticides, may require special handling. See the City and County of Honolulu's web site at www.opala.org for more information or contact the Hawai`i Department of Health.

Teaching Suggestions

1. Display some common household cleaning and garden products in the classroom and conduct a discussion.
   Discussion Questions:
   - Are any of these products familiar? What are they used for and how are they helpful?
   - Do you think any of these products could pollute local streams or the ocean?
   - How would they get from our yards or homes into the streams or ocean?
2. Ask students to describe where they believe water and wastes go after they are washed down the drain or flushed down the toilet. Draw a diagram on the board that traces water and wastes from a kitchen sink to the pipes that connect our homes to the wastewater treatment plant. (Good resources to teach this connection to young students are The Magic Schoolbus at the Waterworks or the color poster produced by the Hawai`i Department of Health. See Suggested Resources.)
3. Discuss how water and wastes are treated before being released a few miles offshore. Note that our treatment plants are sometimes overwhelmed by storm runoff and that raw sewage and other chemical wastes can spill into the nearshore environment.
4. Add storm drains to your illustration and discuss how materials we wash down our driveways or release in our yards (soaps, fertilizers, pesticides, paints etc.) can end up in storm drains that empty into streams and into the ocean. (This is why it's better to wash paintbrushes in the sink and limit use of chemicals on our lawns and gardens.)
5. Distribute the take-home sheet and review it. Ask students to work with a parent to conduct an inventory of products used in and around their homes and to consider some of the healthy alternatives.
6. Display the ingredients for alternative products that have less of an impact on our health and the environment. Have students work in groups to investigate the effectiveness of an alternative product. Students will need to:
   - Select an alternative product from the take-home sheet.
   - Develop a testable hypothesis, for example, "Mixing ¼ cup of baking soda and ½ cup white vinegar with warm water will create a product that will clean our school sink."
   - Use safety procedures to mix the ingredients for the alternative product.
   - Decide on a method for testing its effectiveness.
   - Write a summary and report on their findings.
   - Propose recommendations or modifications based on their findings.
7. When groups complete their investigations, ask them to report to their classmates and discuss their results. Discuss tradeoffs that arise when healthy alternatives are not as effective as some of the commercial products that contain harsh chemicals.

Extended Activities

Have students conduct research to find out how household cleaners, paints, and automotive products such as batteries and used oil should be safely disposed of to avoid risks to people and the environment. See www.opala.org for a kid-friendly site with practical suggestions for reducing, reusing, and recycling. This site also offers guidelines on what to do with used cans of paints and other potentially hazardous materials. Ask students to summarize what they learn and make informational fact sheets to distribute to families.

Conduct investigations in the watershed where your school is located. Have students use water test kits to measure nitrates and phosphates in streams and at the beach. Excess nitrates in the water results from fertilizers that run off into streams and the ocean. Excess phosphates may result from detergents in runoff. These "nutrients" can cause algae to overgrow coral, causing the reef ecosystem to be out of balance. Inexpensive test kits that are easy for students to use are available from:

- LaMotte Company. www.lamotte.com/ P.O. Box 329, 802 Washington Avenue, Chestertown, MD 21260. (800) 344-3100.
- Hach Company. www.hach.com/ P.O. Box 389, Loveland, CO 80539. (800) 227-4224 or (970) 669-3050.

Have students enter the watershed contest sponsored by Protect the Planet and the City and County of Honolulu. See http://www.protecttheplanet.org/ for more information.

Allow students to earn extra credit by responding with a one-page journal entry to the following prompt: Because of the connection between land and sea, I have to be careful to…

References

Moriwake, Isaac. (2004, July). O`ahu Awash in Sewage. Mālama i Ka Honua. Journal of the Sierra Club, Hawai`i Chapter. Vol. 36. No. 3.

Carey, E. (2004, May). Pesticide-Free Ways to Keep Lawn, Garden Healthy. Reprinted from the Toronto Star. Retrieved 7-13-04 from http://www.beyondpesticides.org/main.html.

City and County of Honolulu HI: (n.d.). Household Hazardous Waste. Retrieved on 7-16-04 from www.opala.org.

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Suggested Resources

Cole, J. (1986). The Magic School Bus at the Waterworks. New York: Scholastic.

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Honolulu Board of Water Supply. (n.d.) Water for Life: The History and Future of Water on O`ahu. Honolulu, HI: Info Grafik, Inc. / EMA, Inc. / Honolulu Board of Water Supply.

Moanalua Gardens Foundation and Hawai`i Department of Education. (2001). Watershed Watch. [video] Exploring the Islands Series. Honolulu, HI: Available from DOE Teleschool Branch.

From the Land to the Sea   Student Take-Home Sheet

Did you ever think about how harmful chemicals in products your family uses in the house or in the yard could affect your health? Or that some of these chemicals could make their way into the ocean where they harm our reefs? Your child is participating in the Navigating Change program at school. This program is focused on raising awareness and ultimately motivating people to mālama `āina (care for the land). Please take a few moments to work together to check off the items you use and think about alternatives. Mahalo!

Check If Your Family Uses It	Common Household Products	Some Healthy Alternatives
Home		
	Drain cleaner	Mix 1/4 cup baking soda and 1/2 cup vinegar. Let stand in drain for 5-10 minutes. Flush with hot water.
	Toilet-bowl cleaner	Mix baking soda and castile soap.
	Tub and tile cleaner	Mix 1/4 cup baking soda and 1/2 cup white vinegar with warm water.
	Window cleaner	Mix 2 T. white vinegar with 1 qt. warm water and 2 T. of lemon juice. Wipe windows clean with newspapers.
	Mildew remover	Mix equal parts vinegar and salt. Use some elbow grease (scrub)!
	Furniture polish	Mix 2 parts olive oil to 1 part lemon juice.
	Mothballs	Use cedar chips or dried lavender.
	Rodent poison	Use glue or spring traps.
Yard		
	Chemical fertilizer	Use compost to build up the soil and organic fertilizers such as dried manure and bone meal.
	Bug sprays – pesticides	Place two cayenne peppers, a large onion, and a whole garlic bulb into a blender and mix. Pour into a large container, cover with a gallon of water, and allow to stand for 24 hours. Then strain and spray on plants. (Use caution when handling cayenne peppers!)

Sources: Steelsmith, L. (2004, June). Nonlethal Weapons. The Honolulu Advertiser.
Carey, E. (2004, May). Pesticide-Free Ways to Keep Lawn, Garden Healthy. Reprinted from the Toronto Star. Retrieved 7-13-04 from http://www.beyondpesticides.org/main.html.
City and County of Honolulu (n.d.) Household Hazardous Waste. Retrieved 7-16-04 from www.opala.org.

For information on how to dispose of household and garden chemicals safely, see the City and County of Honolulu's web site at www.opala.org. Neighbor Islands should contact their local state Department of Health office.

You Make the Difference

La Piétra - Hawai`i School for Girls
Environmental Science Class

`A`ohe hana nui ke alu `ia.

No task is too big when done together by all.
— Mary Kawena Pukui, `Ōlelo No`eau #142

You Make the Difference

Photo by Carey Morishige

Early Hawaiians managed the land and water resources within ahupua`a—land divisions that typically ran from the mountains to the sea. People farming and fishing within the ahupua`a recognized the connection between activities on land and the health of the coral reefs in the sea. Wai (fresh water) was considered sacred; it was essential for all life. Wai also connected the land to the sea, carrying nutrients down to the reef. Fishing was regulated by strict kapu (prohibitions) based on the spawning seasons of different fish. Traditional fishing methods and practices enabled Hawaiians to maintain healthy fish populations that sustained them for centuries. Returning to a sense of reverence for the environment that sustains us is a critical need as we witness the deterioration of our land and ocean resources today.

We look to the past for guidance in ways to live sustainably, just as we look to the "kūpuna" islands today for knowledge of what a healthy reef should be. Peering through the clear waters around the NWHI is like seeing through a window to our past where diverse healthy reefs support an astonishing number of large fish. Using this as a baseline for where we are today, we see the deterioration that comes from overfishing, land development, alien species, pollution, and marine debris. Having seen what once was, we have a vision to work toward, to "navigate change" as a way to reach for a better tomorrow.

Communities all over the state are involved in a variety of projects to navigate change. The Navigating Change video provided with this teacher's guide provides a few examples of projects that students are undertaking. These projects provide an inspiration for what we can all do to make the difference. The community resources provided on the following pages await those who are ready to take action!

Community Resources for Taking Action

Note: See the Navigating Change web site www.navigatingchange.org for updates to this list.

Contacts	Description
Create a Watershed Model For application packet and information on deadlines contact: Phone: (808) 527-5699 (Bob Rock) Web site: http://www.protecttheplanet.org/	The purpose of the project is to demonstrate the negative impact of non-point source pollution (NPSP) on our watersheds and ocean. The project achieves this by directly involving students in a hands-on activity for designing, constructing, and demonstrating how land pollution directly affects our marine life and coastal water quality. The watershed models that students create should demonstrate and educate others about being part of the solution and not the pollution. This contest is open to all schools (3rd grade and up), universities (public and private), clubs, organizations, and A+ programs.
Department of Health Clean Water Branch Polluted Runoff Control 919 Ala Moana #301, Honolulu, HI 96814 Lawana Collier Phone: (808) 586-4309	**Water Festival** The Department of Health provides funding for teachers interested in setting up a water festival.
**The Friends of He`eia State Park** Post Office Box 698 46-465 Kamehameha Hwy Kāne`ohe, HI 96744 Phone: (808) 247-3156 Web site: www.inix.com/heeia/ Fax: (808) 247-8510 E-mail: friends@inix.com	The Friends of He`eia invite you to join their community work days, which are held every second and fourth Saturday of the month. Volunteer days focus on gardening and stream restoration. Volunteers help in maintaining and planting a native Hawaiian garden and help with the potting of milo seedlings to be transplanted in the estuary system. Volunteers learn the best techniques for pruning, mulching, transplanting, and much more. The Friends of He`eia are also currently working on restoring the estuary systems through removal of invasive alien mangroves. Volunteers learn to remove alien species from the stream and prevent coastal erosion. They help to pick up marine debris and to plant and mulch native stream flora on the shoreline.
`Imi Pono no ka `Āina Seeking Excellence for the Land Contact: Kuhea Paracuelles Office is located in Hawai`i Volcanoes National Park 808-985-6196 Kuhea_Paracuelles@contractor.nps.gov	Established as an environmental education position on Hawai`i Island under a partnership agreement with the National Park Service, U.S. Army, and U.S. Fish and Wildlife Service, Kuhea designs and facilitates teacher workshops and assists teachers and classrooms with hands-on restoration projects particularly related to native forest restoration.
Kalihi Stream Clean-ups Malama Souza: 236-4400 E-mail: malamasouza@hawaii.rr.com.	The Kalihi Stream Project holds regular stream clean-ups and volunteer work days. Volunteers help remove trash and invasive weeds from Kalihi stream, stabilize stream banks to prevent erosion, and replant native Hawaiian plants.

Contacts	Description
Kuleana Project Mālama o Mānoa For more information, contact Project Coordinator Helen Nakano at 988-5671 or nakano@aloha.net	The purpose of this project is to effect change of activities and practices of 1,000 households in the Mānoa subwatershed on O`ahu. The project engages students in education and outreach utilizing a community-based grassroots approach.
Mālama Hawai`i Volunteer Project web site http://www.malamahawaii.org/get_involved/volunteer.php	Mālama Hawai`i is a hui of over 70 organizations and hundreds of individuals committed to the vision that Hawai`i, our special island home, be a place where the people, land, and sea are cared for, and communities are healthy and safe.
MARE Hawai`i Robin Newbold Education and Research Director 808-875-7661	MARE stands for Marine Awareness, Research, and Education. MARE Hawai`i is a Maui-based nonprofit organization seeking to build on the rich heritage, resources, and talents within the community in order to protect and preserve Hawai`i's coral reef ecosystems. MARE Hawai`i conducts and coordinates ongoing studies of the reef environment using community-based programs such as REEF and Reef Check in order to scientifically document reef status, evaluate conservation efforts, and provide information to management agencies. The organization encourages broad participation through public awareness campaigns, community events, educational initiatives, sponsorship programs, and collaborations with other nonprofit organizations and governmental agencies.
Matson Navigation Donation Program Honolulu, O`ahu Keahi Birch, 848-1252 or Cliff Mattos, 848-1263 Matson Navigation Company 1411 Sand Island Parkway  Hilo, Hawai`i Russell Chin, 961-5286 Matson Navigation Company Pier 1 Kahului, Maui Buzz Fernandez, 871-7351 Matson Navigation Company 105 Ala Luina Street Nawiliwili, Kaua`i Dewayne Kong, 246-9494 Matson Navigation Company Pier 2	Through the Ka Ipu `Āina program, Matson will donate the use of container equipment on O`ahu, Maui, Hawai`i Island, and Kaua`i for environmental clean-up projects arranged by non-profit organizations. Matson will pay for the trucking expenses incurred in the delivery and pickup of the containers. In addition, Matson will make a $1,000 cash contribution to each of the non-profits that successfully complete a cleanup initiative. Matson personnel in each of the Hawai`i offices will work directly with the non-profits to ensure all arrangements are made in the time frame requested. For more details, the non-profit group should call its local Matson contact to request an information packet, which details the program, including requirements and restrictions.

Contacts	Description
Maui County Frog Squad Maui Invasive Species Council: http://www.hear.org/misc/index.html Got Frogs? Flyer: http://www.hear.org/misc/pdfs/misc_got-frogs.pdf Maui County Department of Public Works and Environmental Management: http://www.co.maui.hi.us/departments/Public/ Rob Parsons Maui County Environmental Coordinator E-mail: rob.parsons@co.maui.hi.us for availability of the citric acid	Maui County, Hawai`i, residents are being urged to form frog squads to combat coqui frogs. The Maui Invasive Species Committee (MISC) has joined forces with the county to help landowners rid their properties of the unwanted intruder. The "MISC Got Frogs?" flyer encourages homeowners to work with their neighbors to watch for coqui frogs, and the Maui County Department of Public Works and Environmental Management is providing citric acid to Maui County residents who wish to use it as a pesticide on the frogs.
The Nature Conservancy 923 Nu`uanu Avenue Honolulu, HI 96817  Office Managers/Volunteer Coordinators O`ahu: (808) 621-2008 or (808) 537-4508 Moloka`i: (808) 553-5236 Maui : (808) 572-7849 Hawai`i Island: (808) 885-1786 E-mail: volunteerhawaii@tnc.org	The mission of The Nature Conservancy (TNC) is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. TNC works closely with communities, businesses, and people like you! Help preserve and protect Hawaiian natural areas—there are ongoing volunteer opportunities in the field, baseyard, and office. You can help build and maintain trails and fences, control weeds, out-plant native species, help in the nursery, maintain a resource library, and much more.
Project S.E.A. – Link Liz Foote 32 Polohina Lane #6 Lahaina, HI 96761 Phone: (808) 669 -9062	Project S.E.A.-Link is a non-profit organization based on Maui, Hawai`i. Its mission is to promote marine science, education, and awareness by providing a link between students, teachers, scientists, the local community, the general public, other non-profit organizations, and governmental agencies. Its goals include: encouraging and inspiring the next generation of marine scientists, educators, and stewards of the ocean environment; supporting the inquiry-based reform in science education; and promoting conservation and stewardship in order to preserve and protect marine resources. Project S.E.A.-Link is carrying out its goals through educational programs, the development of an interactive web site providing resources for students and teachers, and through scientific efforts consisting of community-based coral reef monitoring.
Save Our Seas Captain Paul Clark President – Save Our Seas P.O. Box 813 Hanalei, HI 96714 Phone: (808) 651-3452	"Save Our Seas" (SOS) is an international Hawai`i-based non-profit organization that utilizes education and research to preserve, protect, and restore the world's oceans for future generations. SOS project elements include: how to organize and develop stakeholders for community-based support, watershed-based problem identification, the mix of voluntary and regulatory programs, and monitoring and restoring wetlands, coral reefs, and oceanic habitats.

Contacts	Description
Storm Drain Stenciling City and County of Honolulu Phone: (808) 527-5699 (Bob Rock)	This project provides stencils, paint, and brushes for stenciling "dump no waste" messages on storm drains that empty into streams and the sea.
University of Hawai`i's National Science Foundation (NSF) Training Grant Contact: Erin Baumgartner with University of Hawai`i Lab School at (808) 956-4439. Check out the project's web site http://www.hawaii.edu/gk-12/evolution/.	The University of Hawai`i's National Science Foundation (NSF) Training Grant, now approved for 2004 through 2006, provides opportunities for classes to partner with a graduate student to engage your students in an ongoing science-based research project. Students in this Graduate Research Fellowship Program are admitted in the Ecology, Evolution, and Conservation Biology Graduate Program and the fellowship requires them to engage K-12 students in their specific area of research.
Volunteer Hawai`i: http://volunteerhawaii.org/volunteer/	Volunteer Hawai`i is a web site where United Way in Hawai`i provides a clearinghouse for agencies to post volunteer opportunities for the public.
Waimea Valley Audubon Center Kelly Perry, volunteer coordinator Phone: (808) 638-9199 E-mail: kperry@audubon.org	Ongoing volunteer opportunities at Waimea Valley Audubon Center include: moonwalk volunteers, outreach volunteers, Na Po`e Kokua (people helpers), native plant tour docent, Second Saturday `Ohana Series craft and activity helpers, weed and vine removal and general plant and garden care, trail maintenance, and large one-day community projects. Some groups have adopted areas within the park that they help to care for on an ongoing basis. The need is constant, the time commitment flexible.
Waipā Foundation P.O. Box 1816 Hanalei, HI 96714 (808) 826-9969 fax (808) 826-1478 waipa_foundation@yahoo.com http://www.waipafoundation.org/pages/aboutwaipa.html	With the help of many partners, including the Kamehameha Schools Land Assets Division `Āina Ulu Program and the UH Sea Grant Program, the Waipā Foundation is developing projects, programs, and activities in which groups can participate in learning and stewardship opportunities within the context of the ahupua`a. The vision of the Waipā Foundation is to restore the Waipā ahupua`a as a Hawaiian community and learning center, and to create a sustainable culturally and community-based model for land use and management, inspired in part by the traditional values of the ahupua`a.

Hawai`i DOE Content Standards, GLOs, & Nā Honua Mauli Ola	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Gr. 4 Social Studies 1: Historical Understanding: Change, Continuity, and Causality Historical Change and Continuity Nā Honua Mauli Ola #10 Support lifelong aloha for Hawaiian language, history, culture, and values to perpetuate the unique cultural heritage of Hawai`i.	What can we learn from Hawaiian values and practices to guide our interactions with the land and sea today? Activity: The Ahupua`a	• Early Hawaiian practices and the tools and materials Hawaiians used had much less of an impact on the environment than practices and tools of our modern society. • The Hawaiian ahupua`a land management system reflects the Hawaiian value of mālama `āina. • Within the ahupua`a people shared resources and practiced conservation by harvesting only what was needed and by limiting fishing of species during spawning.	4.1.1 Describe both change and continuity of aspects of Hawaiian culture (e.g., religion, land use, social systems).
Gr. 4 Social Studies 7: Geography: World in Spatial Terms Environment and Society Math 3: Numbers and Operations: Computation Strategies Computational Fluency Gr. 5 Math 10: Patterns, Functions, and Algebra: Symbolic Representation Numeric and Algebraic Representations Science 2: The Scientific Process: Nature of Science Unifying Concepts and Themes	What can we do to help restore declining fish populations? Activity: Aunty Ulua	• It is important to leave larger, older female fish in the ocean since they make many more eggs than smaller fish. • When fishing, we observe fishing rules and regulations that are designed to ensure that there will be enough fish for the future.	Social Studies 4.2.1 Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations. (Assessed.) Math 4.3.2 Select and use appropriate strategies and/or tools (e.g., mental math, calculators, paper/pencil, standard algorithms) for computing whole numbers. (Practiced.) 5.10.2 Model problem situations with objects or manipulatives and use representations (e.g., graphs, tables, equations) to draw conclusions. Science 5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Grades 4 - 5 Unit Overview

Hawai`i DOE Content Standards & Nā Honua Mauli Ola	Essential Questions & Activities	Key Concepts	DOE Benchmarks
Social Studies 6: Cultural Anthropology: Cultural Dynamics/ Change and Continuity Cultural Inquiry Language Arts 5: Writing: Rhetoric Meaning Nā Honua Mauli Ola #5 Appreciates and respects the diverse views of others. Becomes actively involved in local activities and organizations that contribute to the quality of life in their community.	How do we "navigate change" to create a healthier environment within our own ahupua`a? Culminating Activity: Navigating Change	• Within our ahupua`a today, we can "navigate change" and work with others in our community to mālama our land and water resources. • It is our kuleana (responsibility) to contribute to the community where we live.	Social Studies 4.6.2 Describe how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a. Language Arts 4.5.1 Use appropriate facts and interesting details that develop the intended meaning and anticipate the needs of the audience. 5.5.1 Use information from appropriate sources: self, peers, and a variety of grade-appropriate sources. 5.5.2 Use significant details and relevant information to develop meaning.

Student Journal

Unit 5 – You Make the Difference

`A`ohe hana nui ke alu `ia.

No task is too big when done together by all.
—Mary Kawena Pukui, `Ōlelo No`eau #142

Student's Name: ______________________

School: ______________________

Date started: ______________________

Date ended: ______________________

Student Assessment Overview

Unit Essential Questions

- What can we learn from Hawaiian values and practices to guide our interactions with the land and sea today (Gr. 4)?
- What can we do to help restore declining fish populations?
- How do we “navigate change” to create a healthier environment within our own ahupua`a?

How you will be graded for this unit:

Individual Journal

It is your responsibility (kuleana) to complete a journal for this unit. Following is a checklist of the pages you will need to include in your journal. Place this page in your journal and make a check next to each item when your complete it. You will be given more details during each lesson.

Journal Pages	3Completed
Gr. 4	
The Ahupua`a – Standard: Social Studies 1 • Draw a picture that shows how early Hawaiians used natural materials to meet their survival needs. • Write a one-page summary describing practices that demonstrated mālama `āina in old Hawai`i compared to modern times. • Compare and contrast materials and products used in old Hawai`i with materials and products used today. (Complete activity sheet.)	
Aunty Ulua – Standard: Social Studies 7 • Write a one-page summary analyzing what happens when people harvest too many fish from a population. • Make recommendations for harvesting the fish sustainably (so there will be enough in the future). Include graphs, sketches, or diagrams to support your conclusions.	
Navigating Change – Standards: Social Studies 6 and Language Arts 5 • Write a reflection about the project you and others do to mālama (care for) your ahupua`a, and explain why the project is important.	
Gr. 5	
Aunty Ulua – Standards: Science 2 & Math 10 • Create a model or simulation to demonstrate how a population of fish could be harvested sustainably (so there will be enough in the future). • Use representations (e.g., graphs, tables, or equations) to draw conclusions. • Describe the model or simulation in your journal.	
Navigating Change – Standards: Language Arts 5 • Write a reflection about the project you and others do to mālama (care for) your ahupua`a, and explain why it is our kuleana (responsibility) to become involved in our communities.	

Culminating Activity – Group Project

This is your opportunity to "navigate change" in your community! Select a problem that you and other students want to address in your ahupua`a. Work with the group to think about ways to help solve the problem by demonstrating mālama `āina (caring for the land and sea). For example, help solve the over-fishing problem by educating others through a group project (web page, song, book, skit, or computer presentation) that you present to the community. Or develop a new project to address a different problem in your ahupua`a.

Your group will need to:

- Identify the problem you want to address in your ahupua`a
- Do some research (Internet, interviews, books) to find relevant facts and interesting information that will help you learn more about the problem and how to address it
- Identify different views of others about the issue or problem and what can be done to resolve conflicts
- Keep a bibliography of your sources of information
- Take pictures or record video segments of your group in action
- Laulima! Work together cooperatively and be sure everyone understands his/her role in the group.

Culminating Activity – Become a "Navigating Change" Reporter

Imagine that you are a television or radio reporter producing a segment on the project that your group completed. Write a two-page script for that segment that summarizes your group project to "navigate change" within your ahupua`a. Each student is responsible for being a reporter and writing his/her own report.

The report should:

- Identify the problem the group tried to solve, including relevant facts and interesting details.
- Describe the action taken to solve the problem, and your conclusions about how well your project worked.

Review the rubric on the following page to see other elements that should be included in your report. Practice reading your script before sharing it with your classmates.

In game show-like fashion, students "navigate change" by testing festival goers about their knowledge of Hawai`i's coral reef animals.

Unit 5 Culminating Activity - Gr. 4

Rubric for Self-Assestment

Student Name________________________________

Nā Honua Mauli Ol & DOE Benchmarks	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Nā Honua Mauli Ola #5 - 3 Learners are able to appreciate and respect the diverse views of others. Points ___	My report described, in great detail, how we appreciate and respect the diverse views of others.	My report described, with detail, how we appreciate and respecte the diverse views of others.	My report described, with minimal detail, how we appreciate and respect the diverse views of others.	My report did not show how we appreciate and respect the diverse views of others.
Nā Honua Mauli Ola #5 – 8 Learners are able to become actively involved in local activities and organizations that contribute to the quality of life in their community Points ___	I described, in great detail, how we were actively involved in the community and really made a big difference.	I described, in detail, how we took action in our community and made a difference.	I described, in some detail, how we took action in our community and made a difference.	I described, in minimal detail, how we took action in our community and made a difference.
Social Studies 6: Cultural Anthropology: Systems, Dynamics, and Inquiry Cultural Inquiry Describe how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a. Points ___	I described, with clear and precise detail, how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a.	I described, with detail, how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a.	I described, with minimal detail, how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a.	I did not describe how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a.
Language Arts 5: Writing: Rhetoric Meaning Use appropriate facts and interesting details that develop the intended meaning and anticipate the needs of the audience. Points ___	My report described our project with lots of relevant facts and interesting details. I used creativity to communicate to my audience.	My report described our project with relevant facts and interesting details.	My report described our project with a few relevant facts but it needed more interesting details.	My report lacked relevant facts and interesting details.

Unit 5 Culminating Activity - Gr. 5

Rubric for Self-Assessment

Student Name______________________________

Nā Honua Mauli Ola & DOE Benchmarks	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	`Ano Mākaukau (Almost at Standard)	Mākaukau `Ole (Below Standard)
Nā Honua Mauli Ola #5 - 3 Learners are able to appreciate and respect the diverse views of others. Points ___	My report described, in great detail, how we appreciate and respect the diverse views of others.	My report described, with detail, how we appreciated and respected the diverse views of others.	My report described, with some detail, how we appreciated and respected the diverse views of others.	My report did not show how we appreciated and respected the diverse views of others.
Nā Honua Mauli Ola #5 – 8 Learners are able to become actively involved in local activities and organizations that contribute to the quality of life in their communites. Points ___	I described, in great detail, how we were actively involved in the community and really made a big difference.	I described, in detail, how we took action in our community and made a difference.	I described, in some detail, how we took action in our community and made a difference.	I described, in minimal detail, how we took action in our community and made a difference.
Language Arts 5: Writing: Rhetoric Meaning Use information from appropriate sources: self, peers, and a variety of grade-appropriate sources. Points ___	My report integrated information from an extensive variety of appropriate sources (from my team and from my own library research, Internet search engines, and/or interviews).	My report used information from a variety of appropriate sources (from my team and from my own library research, Internet search engines, and/or interviews).	My report used information from a few appropriate sources (from my team or from my own library research, Internet search engines, or interviews).	My report used information one or two appropriate sources (from my team or from my own library research, Internet search engines, or interviews).
Language Arts 5: Writing: Rhetoric Meaning Use significant details and relevant information to develop meaning. Points ___	I used significant details and clear, relevant information to insightfully develop meaning in my report.	I used significant details and relevant information to develop meaning.	I used some obvious details and typical information that are related to but do not develop meaning.	I used insignificant details and irrelevant information that do not develop meaning. I can do better work.

The Ahupua`a

Essential Question: What can we learn from Hawaiian values and practices to guide our interactions with the land and sea today?

Hawai`i DOE Content Standard

Social Studies 1: Historical Understanding: Change, Continuity, and Causality – Historical Change and Continuity

- Understand change and/or continuity and cause and/or effect in history.

Grade 4 Benchmark

4.1.1 Describe both change and continuity of aspects of Hawaiian culture (e.g., religion, land use, social systems).

Nā Honua Mauli Ola #10 - 7

Support lifelong aloha for Hawaiian language, history, culture, and values to perpetuate the unique cultural heritage of Hawai`i.

- Learners recognize and identify the healthy cultural behaviors that are practiced and promoted within the environment (kōkua, reciprocity, aloha `āina, mālama `āina).

Key Concepts

- Early Hawaiian practices and the tools and materials Hawaiians used had much less of an impact on the environment than practices and tools of our modern society.
- The Hawaiian ahupua`a system reflects the Hawaiian value of mālama `āina.

Activity at a Glance

Students illustrate tools and materials used to meet human needs in old Hawai`i and compare and contrast these with products used in our modern society. Students compare packaging, products, and practices of today with those of early Hawaiians.

Time

2 - 3 class periods

Assessment

Students:

- Complete an illustration that shows how early Hawaiians used natural materials to meet their survival needs.
- Write a one-page journal entry that describes practices that demonstrated mālama `āina in old Hawai`i compared to modern times.
- Complete a student activity sheet by comparing and contrasting materials and products used in old Hawai`i with those used today.

Rubric

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Analyze both change and continuity of aspects of Hawaiian culture.	Describe both change and continuity of aspects of Hawaiian culture.	Give examples of both change and continuity of aspects of Hawaiian culture.	Recognize both change and continuity of aspects of Hawaiian culture.

Vocabulary

ahupua`a – traditional Hawaiian land division usually extending from mountain summits to the outer edge of the reef
`āina – land; "that which feeds"
kōkua – help, assist
biodegradable – capable of being broken down by natural processes
kapu – taboo; prohibition
mālama `āina – care for the land

Materials

- student journal and assessment pages (provided in Unit Overview)
- student activity sheet (provided)
- reference materials about early Hawaiian life (see list at end of this activity)
- a gourd or lauhala basket
- plastic bag
- drawing paper
- colored markers
- tape or push pins
- large sheet of butcher paper (optional)
- ahupua`a poster (available from Kamehameha Schools Press)

Advance Preparation

Draw a large outline of an ahupua`a on butcher paper or on the board (see illustration on the following page) or use an ahupua`a poster. Make a copy of the student activity sheet for each student and gather some of the suggested references. Also make a copy of the student journal and assessment pages from the Unit Overview for each student.

Background Information

Hawaiian ahupua`a are traditional land units that usually extend from the mountain summits to the outer edge of the reef. Within the ahupua`a, people had access to most of the resources they needed for their survival. They worked together as a community, sharing what they fished and farmed and creating the tools and implements that supported these endeavors. Wai (fresh water) was considered sacred, and reverence for the land and all forms of life was expressed through mālama `āina.

It was common practice to harvest only what was needed and to offer pule (prayers) that expressed aloha `āina. Ali`i (chiefs) imposed kapu (prohibition) on fishing during spawning seasons to ensure that populations of fish would be replenished. Young men trained for years to become knowledgeable in the life history, behavior, and ecology of the fishes before they were allowed to fish (Birkeland & Friedlander, 2001).

As Hawaiian populations grew, agriculture intensified. Extensive irrigation systems were constructed to grow wetland kalo (taro) and in more arid valleys, dryland cultivation was expanded for kalo and sweet potato. Intensified agriculture to meet human needs inevitably

The Ahupua`a

leads to human impact on the environment. Clearing of steep slopes in Hawai`i led to loss of some native species as well as soil erosion and sedimentation in lower valleys (Cuddihy and Stone, 1990).

Human impact on the `āina has intensified with the arrival of people from other parts of the world and the development that has accompanied continued population growth. Today, we import a variety of products and resources, many of which end up in our landfills or on our beaches and roadsides. In our increasingly urbanized ways of life, we tend to lose touch with the land and sea that sustain us. Food comes from the supermarket and water at the turn of a tap. A sense of connection to place can be easily lost as we travel miles out of our home environments and often insulate ourselves from neighbors as we communicate across the Internet and seek entertainment from computer games and televisions. The many luxuries that we enjoy in our modern world come with costs that go beyond the price tag. Today we struggle with overflowing landfills, illegal dumping, marine debris, polluted and overfished waters, and a need to reconnect with our communities and the `āina in a meaningful way.

Looking to the past, we see ways to carry forward Hawaiian values and practices that bring us closer to the land and sea, and closer together in communities within ahupua`a. Mālama `āina is a guiding light that shines toward a brighter, sustainable future if we choose to follow it.

Note: If you need assistance identifying the ahupua`a where your community is located, ahupua`a maps for each of the main Islands are available from the Let's Go Voyaging Teacher's Guide. See Resources listed at the end of this activity.

Teaching Suggestions

Introducing the Unit:

Distribute the student journal and assessment pages and use these documents to introduce students to the unit. Review the projects and assignments and discuss the journals that students will be producing. Set a deadline for the culminating project and review the sample rubric.

1. Use the large outline drawing you have prepared to introduce students to the Hawaiian ahupua`a. Share stories and/or pictures about life in old Hawai`i. (See suggested references listed at the end of this activity.) If time allows, begin this activity by having groups of students make models of an ahupua`a.
2. Ask students to imagine that they were living in this ahupua`a hundreds of years ago. Ask them to discuss what life might have been like.
   - Where do you get the resources needed for food, shelter, and clothing?
   - What kinds of tools do you have to farm, fish, and make clothing?
   - How did children help their families to meet their needs?
3. Distribute the student activity sheet and divide the class into six groups. Assign each group to one of the categories on the sheet.
   - clothing
   - shelter
   - tools for fishing
   - tools for farming
   - tools for cooking
   - toys/recreation
4. Distribute drawing paper and colored markers. Show students the reference materials and ask them to:
   - Find information related to their category.
   - Illustrate a part of the ahupua`a showing people using the tools or materials in their category.
   - Report on how the value of mālama `āina was evident in the Hawaiian way of life. Prepare a group presentation to share what they have learned with their classmates.

5. As each group presents its findings, ask students to fill in their activity sheets with information about the materials used in early Hawai`i. If they are not familiar with the process of taking notes, review how to listen and record key ideas. Have a spokesperson from each group then read what notes were recorded and have students post their drawings within the large ahupua`a you have outlined.

6. Next to the ahupua`a illustration make a list of all the raw materials that were needed (i.e., wood, feathers, stone, shells, plant fibers). Conduct a discussion about these materials and about life in old Hawai`i.
   Discussion Questions:
   - What do all of these materials have in common? (They are made from natural materials.)
   - What was used to carry or "package" things that they used? (Gourds, lauhala baskets, ti leaves.) Display the items you have brought and discuss how natural products are different from the packaging we use today.
   - What would happen to the items when they were worn out? (They would decompose and become part of the soil.)
   - Do you think any of these materials polluted the stream and ocean? (No. Early impact on the environment may have resulted from other causes such as soil erosion after clearing large areas of forested land to make way for crops.)
   - How did people share resources within the ahupua`a? (Farmers and fishers shared foods.)
   - How is conservation and the value of mālama `āina practiced within the ahupua`a? (Kapu on fishing during spawning; offering pule (prayers) before harvesting; taking from nature only what is needed.)


Photo by Polynesian Voyaging Society

7. Turn the clock forward to the present day. Ask each group to brainstorm a list of modern-day products that would compare to the materials used in old Hawai`i and fill those items in on their activity sheets in the column labeled "Some Examples Today." Discuss their ideas and make a list on the board of the raw materials that are used to make these products (i.e., wood, plastics, rubber, metals, etc.). Have students compare and contrast these raw materials with the materials used in early Hawai`i.
   Discussion Questions:
   - What do the modern products and tools have in common? (Many are manufactured from human-made substances; many are heavily packaged in plastic and Styrofoam.)
   - How else are they different from the products and tools created in old Hawai`i? (Many products are shipped here instead of being locally made, and many are non-biodegradable.)
   - What kinds of products do we use today that were not available in old Hawai`i? (Electronic equipment, vehicles, books, plastic toys, chemicals for cleaning, fertilizers, pesticides, processed foods, disposable diapers, utensils etc.)
   - What happens to our products when we throw them away? (They get buried in landfills, incinerated, or [hopefully] recycled into something to be used again.)
   - Which of our modern-day products pollute the streams and ocean?

8. Discuss Hawaiian values and practices related to mālama `āina (caring for the land), kōkua (assisting, helping), reciprocity, aloha `āina (love for the land), and laulima (working together). Ask students to come up with examples of actions we can take to mālama `āina in the ahupua`a where we live. Some examples are to buy items that are not in heavy packaging, to refuse bags if we don't need them, and to choose locally made products when possible.

9. Ask students to write one-page journal entries that describe practices that demonstrated mālama `āina in old Hawai`i compared to modern times.

How Long Will It Take to Break Down?

Glass bottle	1 million years
Monofilament fishing line	600 years
Plastic beverage bottle	450 years
Disposable diaper	450 years
Aluminum can	80 - 200 years
Foamed plastic buoy	80 years
Rubber boot sole	50 - 80 years
Foamed plastic cup	50 years
Tin can	50 years
Leather	50 years
Nylon fabric	30 - 40 years
Plastic film canister	20 - 30 years
Plastic bag	10 - 20 years
Cigarette filter	1 - 5 years
Wool sock	1 - 5 years
Plywood	1 - 3 years
Waxed milk carton	3 months
Apple core	2 months
Newspaper	6 weeks
Orange or banana peel	2 - 5 weeks
Paper towel	2 - 4 weeks

Information Source: US National Park Service; Mote Marine Lab, Sarasota, FL. Retrieved July 27, 2004 from, http://sacoast.uwc.ac.za/education/resources/marinedebris/index.htm. Pocket Guide to Marine Debris. (n.d.). The Ocean Conservancy and The U.S. Environmental Protection Agency.

Extended Activities

Invite a kupuna (elder) to come and speak to the class about Hawaiian conservation practices and early kapu (taboo) related to harvesting natural resources. Ask students to create a list of these practices and place it next to the ahupua`a illustration.

Take a class field trip to Bishop Museum where students can learn more about the implements and clothing items used in old Hawai`i.

Have students conduct an experiment to determine how long it takes various items to decompose. Students could bury a few items within the top layer of soil on the school grounds and dig the items up after a month to see how much has decomposed. Some rates of decomposition are provided in the box above.

Ask students to write one-page journal entries to respond to one of the following prompts:

- The Hawaiian value of mālama `āina is important to me because…
- I kōkua (help) to conserve resources by…

References

Birkeland, C. & Friedlander, A. (2001). The Importance of Refuges for Reef Fish Replenishment in Hawai`i. Honolulu, HI: The Hawai`i Audubon Society, Pacific Fisheries Coalition.

Cuddihy, L.W. & Stone, C.P. (1990). Alteration of Native Hawaiian Vegetation. Honolulu, HI: Cooperative National Park Resources Studies Unit, University of Hawai`i, Mānoa.

References for Students

Williams, J.S. (1991). From the Mountains to the Sea: The Ahupua`a. Kamehameha Schools Intermediate Reading Program. Honolulu, HI: Kamehameha Schools.

Dunford, B. (1997). Hawaiians of Old. Honolulu, HI: Bess Press.

Honolulu Board of Water Supply. (n.d.) Water for Life: The History and Future of Water on O`ahu. Honolulu, HI: Info Grafik, Inc./EMA, Inc./Honolulu Board of Water Supply.

Mitchell, D.D. K. (1982). Resources Units in Hawaiian Culture. Honolulu, HI: The Kamehameha Schools.

Moanalua Gardens Foundation and Hawai`i Department of Education. (2001). Wai Ola: Water of Life. [video] Exploring the Islands Series., Honolulu, HI: Available from DOE Teleschool Branch.

Titcomb, M. (1974). The Ancient Hawaiians: How They Clothed Themselves. Honolulu, HI: Hogarth Press.

Resources

Lucas, K. & O'Connor, M. (1999). Let's Go Voyaging Teacher's Guide. Honolulu, HI: Moanalua Gardens Foundation. (Ahupua`a maps are included in the teacher's guide and can be downloaded from the Moanalua Gardens Foundation web site. See http://www.mgf-hawaii.com/. Click on Resources to locate the guide.)

Materials & Products	In Old Hawai`i	Some Examples Today	How are modern products different?
Clothing			
Shelters			
Tools for Fishing			
Tools for Farming			
Tools for Cooking			
Toys/ Recreation			

The Ahupua`a — Teacher Answer Sheet

Materials & Products	In Old Hawai`i	Some Examples Today	How are modern products different?
Clothing	kapa made into: malo (loincloths) pa`ū (skirts) kīhei (cloaks) lauhala sandals ti leaf capes feather capes and helmets (tools – kapa beaters, dyes, kapa boards)	t-shirts, shorts, pants, dresses, slippers, athletic shoes, socks, sweaters, jackets (tools – sewing machines)	• Made from new human-made materials (nylon, polyester) • People use more. • Products are shipped to the islands. Packaging includes boxes, bags, cardboard, and plastic wrapping.
Shelters	pili grass (thatch) wood stones kapa lauhala mats	wood, glass, concrete, stone, bricks, plastic siding, tile, tar and other roofing shingles, carpeting, tiles, linoleum	• Made from new human-made materials • Houses are bigger and use many more products.
Tools for Fishing	wood and shell fishhooks cordage fishing line nets from cordage hala floats for nets cowry shell lures lauhala baskets `ie`ie fish traps canoes	metal fishhooks nylon lines and nets fiberglass boats motors run with gas coolers with ice radios and other devices on boats plastic floats and lures	• Made from new human-made materials • Use fossil fuels • Harvests are larger.
Tools for Farming	`ō`ō (digging stick) natural fertilizers stone adze baskets for harvesting stones for walls wooden drills for making tools	tractors, chemical products (fertilizers and pesticides), packaged seeds from many places, pvc pipes, plastic and rubber hoses, watering systems, chain saws	• Made from new human-made materials • Use fossil fuels • Harvests are larger.
Tools for Cooking	stones ipu (gourds) `opihi (limpet) shells wooden utensils	stoves, refrigerators, pots and pans, blenders, food processors, microwave ovens, toasters, dishwashers, plastic containers, dishes, glasses	• Made from new human-made materials • Use fossil fuels • Use chemical soaps to clean
Toys/ Recreation	wooden surfboards ula maika (stone disks) coral and pebbles (for kōnane, a game similar to checkers)	balls, dolls, surfboards, flippers, tennis rackets, computers, electronic games, CD and DVD players, televisions, bicycles, scooters, books, paints	• Made from new human-made materials (nylon, polyester) • People use more. • Products are shipped in. • Packaging includes boxes, bags, cardboard, and plastic wrap.

Aunty Ulua

Essential Question: What can we do to help restore declining fish populations?

Hawai`i DOE Content Standards

Social Studies 7: Geography: World in Spatial Terms – Environment and Society

- Use geographic representations to organize, analyze, and present information on people, places, and environments and understand the nature and interaction of geographic regions and societies around the world.

Math 3: Numbers and Operations: Computation Strategies – Computational Fluency

- Use computational tools and strategies fluently and, when appropriate, use estimation

Math 10: Patterns, Functions, and Algebra: Symbolic Representation – Numeric and Algebraic Representations

- Use symbolic forms to represent, model, and analyze mathematical situations.

Science 2: The Scientific Process: Nature of Science - Unifying Concepts and Themes

- Understand the science, technology, and society are interrelated.

Grades 4 - 5 Benchmarks

Social Studies

4.2.1 Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations. (Assessed.)

Math

4.3.2 Select and use appropriate strategies and/or tools (e.g., mental math, calculators, paper pencil, standard algorithms) for computing whole numbers. (Practiced.)

5.10.2 Model problem situations with objects or manipulatives and use representations (e.g., graphs, tables, equations) to draw conclusions.

Science

5.2.1 Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Key Concepts

- It is important to leave larger, older female fish in the ocean since they make many more eggs than smaller fish.
- When fishing, we should observe fishing rules and regulations that are designed to ensure that there will be enough fish for the future.

Activity at a Glance

Students conduct a fishing demonstration in the classroom and then develop geographic representations (graphs, sketches, or diagrams) or models or simulations to summarize what they have learned about sustainable fishing practices.

Prerequisite Activity: "Looking Back" Unit 3

Time

2 - 3 class periods

Assessment

Students:

- Complete a project (poster, web page, song, poem, computer presentation, etc.) that communicates sustainable fishing practices.
- Write a one-page journal entry that analyzes the consequences of over-harvesting a population of fish. Make recommendations for harvesting fish sustainably and include graphs, sketches, or diagrams to support conclusions (Gr. 4).
- Create a model or simulation to demonstrate how a population of fish could be harvested sustainably and use representations (e.g., graphs, tables, equations) to draw conclusions. Describe the model in their journals (Gr. 5).

Rubrics

Gr. 4

Advanced	Proficient	Partially Proficient	Novice
Evaluate the consequences of human modification of the physical environment in Hawai`i using geographic representations, drawing relevant and insightful conclusions.	Analyze the consequences of human modification of the physical environment in Hawai`i using geographic representations, drawing relevant conclusions.	Describe the consequences of human modification of the physical environment in Hawai`i using geographic representations.	Recognize, with assistance, the consequences of human modification of the physical environment in Hawai`i using geographic representations.
Select appropriate strategies and/or tools for computing whole numbers, justify the selection, and apply the strategies, with accuracy.	Select appropriate strategies and/or tools for computing whole numbers and apply the strategies, with no significant errors.	Select appropriate strategies and/or tools for computing whole numbers and apply the strategies, with a few significant errors.	Select inappropriate strategies and/or tools for computing whole numbers; or apply strategies, with many significant errors.

Lanikai Public Charter School students install signs they created to help mālama the Mokulua Islands

Advanced	Proficient	Partially Proficient	Novice
Model problem situations with objects or manipulatives and use representations to draw conclusions, with accuracy.	Model problem situations with objects or manipulatives and use representations to draw conclusions, with no significant errors.	Model problem situations with objects or manipulatives and use representations to draw conclusions, with a few significant errors.	Model problem situations with objects or manipulatives and use representations to draw conclusions, with many significant errors.
Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world.	Use models and/ or simulations to represent and investigate features of objects, events, and processes in the real world.	With assistance, use models or simulations to represent features of objects, events, or processes in the real world.	Recognize examples of models or simulations that can be used to represent features of objects, events, or processes.

Vocabulary

kuleana – responsibility
reproductive size – the size of an organism when it is sexually mature
L_{50} – the length (L) of a fish species at the time when approximately 50% are reproductively mature (only half will be able to spawn at that size)
sustainable use – use of a resource in a way that allows future generations to meet their needs

Materials

- Actual Reproductive Size fish poster (provided)
- Photo CD (provided)
- rulers
- large sheets of drawing paper
- scissors
- color markers
- craft materials (paints, poster paper)

Advance Preparation

Locate the ulua photos in the fish file on the Navigating Change photo CD and the "Comparing Ecosystems" PowerPoint presentation on the CD.

Background Information

"The very high biomass of apex predator reef fish in the NWHI is perhaps unique in the world and a reflection of long periods without fishing pressure."

—Alan Friedlander, Oceanic Institute (Maragos & Gulko, 2002)

The biomass of marine life (total weight of living things in a defined area) in the NWHI is three times that of the MHI. The coral reefs of the NWHI have many more apex predators, such as sharks and ulua, than the MHI. The presence of these animals in large numbers is generally indicative of a healthy ecosystem since there has to be sufficient numbers of species to support them. In contrast, the coral reefs of the MHI are mostly composed of small size, low-level carnivores and herbivores. The near absence of apex predators is attributed mostly to overfishing (Maragos & Gulko, 2002).

Overfishing or fishing pressure has reduced many nearshore fish populations in the MHI to levels below the capacity of the fish resources to replenish themselves (Birkeland & Friedlander, 2001). The loss of traditional controls on fishing in the last 200 years, combined with a growing human population, coastal development, habitat loss, sedimentation, invasive species, and the use of modern technology, has contributed to decreased fish populations. Technology such as high-powered boats, scuba-diving gear, underwater lights, and large monofilament nets has increased fish harvests. When the relatively inexpensive gill nets are abandoned, they can float through the ocean and "ghost-fish" for years, further depleting our coral reefs.

How do we work to replenish our overfished stocks in nearshore waters around the MHI? Fishing rules and regulations, including minimum catch size, bag limits, and closed seasons are one way to address the issue. The minimum catch size (for most species) allows the fish to grow to a size where they are reproductively mature. The poster that accompanies this activity, beautifully illustrated by Ellyn Tong, shows the fish at their actual reproductive size. This is referred to as L_{50} —the length (L) of a fish species at the time when approximately 50% are reproductively mature (only half will be able to spawn at that size). The larger, older females at their reproductive peak are able to produce many more eggs than smaller fish. Their larger body size allows them to produce and hold more eggs. Allowing the big "aunty" fish to survive helps to increase the fish population. The bigger females are also capable of making eggs with bigger yolks, which helps the fish larvae to survive during that crucial first few weeks of life (Tong, 2003). Once the fish are past their reproductive peak, their production of eggs decline.

The Hawai`i Department of Land and Natural Resources, Division of Aquatic Resources is charged with developing and enforcing minimum catch size and other fishing regulations. However, securing adequate funding for enforcement and enforcement officers has been difficult, and enforcement of fishing regulations and rules often poses serious challenges. It takes commitment on the part of caring and informed individuals to conserve our fisheries for today and for future generations.

With the serious decline in our nearshore fisheries, it may be that establishing more marine refuges as a management tool is the answer for fish to recover. These refuges are areas where fishing is prohibited so that fish populations can be restored. According to Birkeland and Friedlander (2001), there is overwhelming evidence that fully protected marine refuges will rapidly enhance resident fish populations, while other management strategies such as quotas, size limits, gear restrictions, or temporary closures of fishing grounds have consistently failed over the years.

Teaching Suggestions

1. Ask students what the presence of many large apex predators, such as ulua (giant trevally) and manō (sharks), on reefs in the NWHI indicates about the health of those reefs compared to the MHI. Discuss the fact that the NWHI reefs are healthy enough to support large populations of apex predators. When reefs are overfished or damaged by sedimentation and pollution, or invasion by invasive species, the large apex predators don't have enough food to survive.

2. Show photos of the huge ulua provided on the photo CD. Ask students why they think we don't see many large ulua around the MHI today.

3. Show students the color poster of fish that are drawn to their actual reproductive size. Discuss what the L_{50} for fish means and why it is important for fishers to understand this concept. Point out the ulua (giant trevally) on the poster and ask a student to read the data provided about its reproductive size and the legal size for fishing.

4. Distribute large sheets of drawing paper, color markers, and rulers and ask students to help create a fishing demonstration. The class should make at least 24 large and 24 smaller fish. Have each student:
   - Create a cut-out of the ulua at its L_{50} size (21 – 32 ")
   - Make a second cut-out of the fish at half the L_{50} size.

5. Conduct a fishing demonstration.

   <u>Set-up</u>
   - Place 24 large ulua fish cut-outs in the center of a cleared area of the classroom to represent the ocean fishing grounds.
   - Have half of the students sit in a circle around the fish. Give each of them 2 small ulua fish to hold on their laps.
   - Have the remaining students form 4 fishing teams and stand with their teammates in a circle around the fishing area. These are the fishers who will harvest fish from the "ocean."

   <u>Fishing</u>
   - When a signal is given, fishing groups may begin "fishing." They may harvest as many fish as they want during each fishing trial.
   - Call "Time" after 15 seconds. Collect all of the fish that were taken from the "ocean." Count the number of ulua remaining. For every 2 ulua remaining, students may replenish the fishing grounds with 1 baby ulua (L_{50}). If all fish are removed during the first trial, that provides an opportunity to discuss what would happen for future generations!
   - There will be four 15-second fishing trials. At the fourth trial, half of the baby ulua remaining in the ocean will have grown into adults (switch small fish for large fish that were caught previously.) The other half will be eaten by predators (remove from the demonstration).

6. Discuss the fishing demonstration.

   <u>Discussion Questions</u>
   - Why weren't more ulua added to the ocean when only small ulua remained in the fishing grounds? (The baby ulua were not large enough to reproduce.)
   - How could we change our fish harvest so that the ulua population would not be depleted? (Develop fishing regulations and follow them.)
   - How could we fish sustainably—that is, take some now and leave enough for future generations—while maintaining the dynamics of a healthy fish population?
     Give students time to think about this and to come up with proposals.
     Note: If fishers take no more than four of the adults in each trial and harvest no babies, the results are displayed on the following page.

Trial 1 24 a (adults)	Fishers take - 4 a (adults)	20 a remain 10 b (babies) added	Total 20 a 10 b
Trial 2 20 a 10 b 30 fish	Fishers take - 4 a	16 a remain 10 b remain + 8 b added	16 a 18 b
Trial 3 16 a 18 b 34 fish	Fishers take - 4 a	12 a remain 18 b + 6 b added	12 a 24 b
Trial 4 12 a 24 b 36 fish	Fishers take - 4 a	8 a remain 24 b - ½ grow up +12 a - 12 b lost to predators + 10 b added	20 a 10 b 30 fish

- What would happen to our fish population if we added mortality (death) of one quarter of the fish after each trial as young ulua became prey, or old fish died due to natural causes or marine debris (getting caught in net or swallowing plastics)?
- What would happen if we had a closed season or kapu during the time the fish were spawning?
- What are the consequences if we all just take what we want?

7. Have students switch places and conduct the demonstration again using the regulations that they wish to impose.

8. Show the "Comparing Reefs" PowerPoint presentation (provided on the photo CD) and review what happens if we let `ōmilu grow to larger size and produce more eggs.

9. Ask students to each select one fish from the actual reproductive size fish poster and complete these tasks:
   - Create a project (poster, web page, song, poem, computer presentation, etc.) that communicates sustainable fishing practices.
   - Research current fishing regulations developed by the Hawai`i Department of Land and Natural Resources, Division of Aquatic Resources, and add that information to their projects. See www.hawaii.gov/dlnr/dar.

10. Provide time for students to complete the assessment activities and reflect in their journals. Note: Students may wish to present their projects as part of the culminating activity for this unit.

Extended Activities

Conduct a mock town meeting in class around the issue of establishing a marine refuge that would close a popular fishing area to fishing. Ask a few students to serve as the town council. Ask others to form teams that play the role of commercial fishers, recreational fishers, and marine biologists. Give teams a class period to prepare their arguments for or against the marine refuge and ask the town council to research the issue and come up with criteria for making their decision. Have students discuss the council's decision and how difficult it can be to respect the diverse views of others. For information on the process of developing a national marine sanctuary, see http://www.hawaiireef.noaa.gov/designation/welcome.html.

Visit the Pacific Fisheries Coalition web site for educational materials and information on fisheries. The Pacific Fisheries Coalition is a collaboration between conservationists and fishers to promote the protection and responsible use of marine resources through education and advocacy in Hawai`i and the Pacific. http://www.pacfish.org/education/.

Explore with students why predators, such as large ulua, are an important and necessary part of all ecosystems. The predators regulate all the species below them and help to promote healthy and diverse populations within their prey species. For additional background information on this important topic, see the University of Michigan's web site on global change at: http://www.globalchange.umich.edu/globalchange1/current/lectutes/predation/predation.html.

Provide students with extra credit for responding with one-page journal entries to one of the following journal prompts:

- If I wrote fishing regulations, I would propose…
- In order to have enough fish for future generations it is our kuleana to…

References

Birkeland, C. & Friedlander, A. (2001). The Importance of Refuges for Reef Fish Replenishment in Hawai`i. Honolulu, HI: The Hawai`i Audubon Society, Pacific Fisheries Coalition.

Maragos, J. & Gulko, D. (Eds). (2002). Coral Reef Ecosystems of the Northwestern Hawaiian Islands: Interim Results Emphasizing the 2000 Surveys. Honolulu, HI: U.S. Fish and Wildlife Service and the Hawai`i Department of Land and Natural Resources.

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The Mālama Kailua Festival 2005
Photo by Katie Laing:

Navigating Change

Essential Question: How do we "navigate change" to create a healthier environment within our own ahupua`a?

Hawai`i DOE Content Standards

Social Studies 6: Cultural Anthropology: Systems, Dynamics, and Inquiry – Cultural Inquiry
- Understand culture as a system of beliefs, knowledge, and practices shared by a group and understand how cultural systems change over time.

Language Arts 5: Writing: Rhetoric - Meaning
- Use rhetorical devices to craft writing appropriate to audience and purpose.

Grades 4 - 5 Benchmarks

Social Studies
- 4.6.2 Describe how individuals or groups deal with conflict, cooperation, and interdependence within the ahupua`a.

Language Arts

4.5.1 Use appropriate facts and interesting details that develop the intended meaning and anticipate the needs of the audience.

5.5.1 Use information from appropriate sources: self, peers, and a variety of grade-appropriate sources.

5.5.2 Use significant details and relevant information to develop meaning.

Nā Honua Mauli Ola #5 – 3, 5 - 8

Provide safe and supportive places to nurture the physical, mental/intellectual, social, emotional, and spiritual health of the total community.
- Appreciates and respects the diverse views of others.
- Becomes actively involved in local activities and organizations that contribute to the quality of life in the community.

Key Concepts

- Within our ahupua`a today, we can "navigate change" and work with others in our community to mālama (care for) our land and water resources.
- It is our kuleana (responsibility) to contribute to the community where we live.

Activity at a Glance

Students collaborate with classmates to plan and carry out projects that contribute to a healthier environment in their community. They take on the role of television or radio reporters and write scripts to describe their projects.

Time

4 – 5 class periods (or longer depending on students' projects)

Assessment

Students:
- Complete a project to mālama the environment within their ahupua`a and write a journal reflection that summarizes their project and explains why it was important (Gr. 4) and explains why it is our kuleana (responsibility) to become involved in our communities (Gr. 5).

- Write individual scripts for a media report that describes the project. (See Student Assessment Overview and rubrics provided for more details on criteria for reports.)

Rubric (Provided in Student Assessment Overview)

Vocabulary

laulima – work together
diverse – differing from one another; having various forms or qualities

Materials

- Navigating Change video segment "You Make the Difference" (provided)
- action plan student sheet (provided)
- community resources list (provided in Unit Introduction)

Advance Preparation

Make a copy of the "Student Action Plan" sheet for each student. Review culminating activity rubrics with students.

Background Information

Taking collective action to "navigate change" for a healthier environment challenges students to apply what they have been learning to real-world situations. Taking action involves many skills, including critical thinking, organization, advocacy, communication, and collaboration. Perhaps most importantly, it allows students to see that each of us truly can make the difference.

The action plan provided in this instructional activity and the list of contacts for conducting projects (provided in the Unit Introduction) are presented as guidelines for students. The actual projects that students undertake should be determined by their interests and the needs in your community. The Navigating Change team encourages students to send summaries and pictures of students in action for posting on the project web site. Please send to Andy Collins at the NOAA office: andy.collins@noaa.gov. As these projects are posted for others to see, students' actions will motivate, encourage, and challenge us to take care of our land and sea.

Teaching Suggestions

1. Show the Navigating Change video segment "You Make the Difference" and discuss it with your class. What kinds of actions were students involved in to mālama their environment?

2. Create two columns on the board and label them: 1) "environmental problems in our ahupua`a," and 2) "navigating change." Ask students to make a list of environmental concerns and write their ideas on the board. Brainstorm positive ways to address each concern and list these under "navigating change." (Note: If students need help determining the boundaries of the ahupua`a where your school is located, refer to the Let's Go Voyaging materials available at http://www.mgf-hawaii.org under resources.)

3. Ask students if they believe everyone has the same point of view regarding how environmental problems should be solved. For example, some commercial fishers may have different points of view about overfishing than marine biologists. Discuss why it is important to appreciate and respect diverse views.
   <u>Discussion Questions:</u>
   - How are people or groups within our ahupua`a interdependent?
   - Give an example of ways in which people can cooperate to accomplish something important in our ahupua`a.
   - Give an example of ways that people with different points of view can resolve conflicts.

4. Ask students to decide on a project (either the whole class or small group) that they would like to plan and carry out to address a problem related to the environment in their ahupua`a.

Discuss the individual reports that students will need to complete for their culminating projects. Ask them to think about what they will need to do during their projects in order to write a media report about it. For example, take notes of significant events or interviews, take pictures, or record videos.

5. Distribute the action plan sheet to students and review it with them. Refer to the sample plan below.

Sample Action Plan

Steps	Notes
Describe the problem to be addressed.	For example: overfishing in our ahupua`a
List alternative actions to take.	• Produce educational Public Service Announcements and submit them to `Ōlelo for airing on community television. • Paint posters with messages about caring for our ocean resources and display them in public areas. • Create colorful minimum catch-size rulers with information on fishing regulations (bag limits and minimum size) and distribute them in the community. • Conduct a "Fishing Fair" for the school community that includes games, educational displays, and speakers such as elder fishers who can provide some perspective of changes over time. • Conduct a study to determine the abundance of fish in the reef ecosystem.
Discuss potential difficulties with your action ideas and how to overcome them. Select an action project.	• Lack of interest or conflicts in the community: Interview friends and relatives and share fishing facts with them. • Lack of funding to put on a dynamic fair: Conduct a fund-raising event or ask for donations from the community. • Need for community resource person to help guide effort: Contact resource person from list provided in the Unit Introduction.
Develop a timeline to implement the plan by the due date.	• List all of the steps involved including researching, interviewing, creating materials, etc.
Divide tasks among group members and be sure everyone understands roles.	• Names Tasks

Take action!	• Conduct research to gather some facts, data, or evidence about your problem. • Cite your references for research. (Show standard way of citing references.) • Carry out your plan. • Take on the role of a television or radio reporter and write a script for a report that describes your project. The report should include how you considered diverse views of others. • Ask others in your group to review your report and provide feedback. Make revisions based on feedback.
Assess the effectiveness of action taken.	• Describe what worked well to accomplish your goal. (How did people cooperate and resolve conflicts?) • List what could be done to carry on the effort or improve on it.

6. Guide students through the planning process and help them to establish a timeline that will lead to completing the project by the due date.
7. Ask groups to share their completed plans and ideas with the class. Have groups give feedback to one another and discuss the merits of their plans.
8. When projects are completed, ask students to write a reflection in their journals and complete their media scripts that describe their group's project. Encourage students to practice reading their scripts and set aside time for students to be "reporters" on the scene and share what their group accomplished.

Extended Activities

Teacher Reni Bello from Waialua High and Intermediate School had her students each think carefully about a promise they could make to a kūpuna (elder) to mālama their environment. Students thought long and hard about meaninful promises they could make, and shared them with their chosen kūpuna. They then wrote their promises on paper and placed them in their wallets, carrying the reminders with them. Mahalo, Reni, for sharing this activity with us! Hopefully others will be inspired to try this or a similar activity with their students.

Students could make an interactive "Aunty Fish" display for others in the school to learn about fishing rules and regulations designed to conserve fish populations. Ask students to each create a color cut-out of a big aunty fish using the "Actual Reproductive Size" poster as a guide. They could include the L_{50} size information, fishing regulations, and the name of the fish on the reverse side of the cut-out. The fish cut-outs could be attached to a display board so that they flip up to reveal information on the back. The header for the display could challenge users to identify: "Who am I and how big do I need to be before you catch me?"

Have students write letters to the editor of the local newspaper to communicate their concerns about declining fish populations and what can be done to increase the number of fish in nearshore environments.

Students could write letters to the Division of Aquatic resources recommending rule changes for species that are legally harvested at a size below the L_{50} size.

Allow students to earn extra credit by writing one-page responses to the following journal prompt:

- It is important to get involved in your community because…

Student Action Plan

Name ______________________ Project Due Date ______________________

The problem we want to help solve is:

____

____

Some different actions we could take to help solve the problem are:

-
-
-
-
-

After discussing potential difficulties with the actions listed above, we decided on the following action.

Our Action Project is:

____

____

____

Laulima! Work together!

Names of Group Members	Kuleana (Responsibility)

On the other side of this sheet, list all the steps you will take, such as researching, interviewing, and creating materials. Be sure to cite references for your research. List the dates when you plan to complete each step—this will be your action timeline!

Write a report that describes your project. The report should include how you considered diverse views of others. Ask students in your group to review your report and provide feedback. Make revisions based on their feedback.

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Description of Hawaiian Names Given to the NWHI

An important aspect of Hawaiian culture is the awareness that in numerous instances traditional place names either were replaced with foreign ones or the Hawaiian names were misspelled to the degree that their meanings were changed. The Hawaiian Lexicon Committee from the University of Hawai`i, Hilo (UH-Hilo) has given names to some places in the Northwestern Hawaiian Islands (see list below). Other groups are currently researching the traditional ancient names for these islands. When the results of that research are available, they will be included on the project web site (see www.navigatingchange.org).

Mokumanamana (Necker Island) – The traditional name. A small basaltic islet with numerous heiau (shrines).

Kānemiloha`i (French Frigate Shoals) – An atoll of reefs, low sand islets, and the 120-foot-high La Pérouse Pinnacle. This shoal-like place is thought to have been the place where one of Pele's brothers was left as a guard during the voyage to Hawai`i from Kahiki. Its name commemorates Kānemiloha`i.

Pūhāhonu (Gardner Pinnacles) – Means "surfacing of a turtle for air." These two isolated islands and various rock outcroppings seem to appear unexpectedly to voyagers at sea, like a turtle coming up for air, its back and head emerging above the surface. Although turtles are rarely sighted on land in the main islands, often they can be seen resting on crevices and rock ledges at Pūhāhonu.

Ko`anako`a (Maro Reef) – Because this atoll is generally covered by breakers, this Hawaiian name translates as "surf that arrives in combers."

Kauō (Laysan Island) – This flat island, bordered by sand and surf and harboring a pond, resembles a bird's egg, cracked open, with the yolk surrounded by egg white. Kauō can be either the yolk or the egg white, its meaning specified with the modifier melemele (yellow) or ke`oke`o (white). Denoting the contents of an egg, the name Kauō also signifies the thousands of birds that inhabit the island.

Papa`āpoho (Lisianski Island) – The literal translation describes the physical appearance of Papa` āpoho, a flat (island) with a depression.

Holoikauaua (Pearl and Hermes Atoll) – This atoll is named for the endangered Hawaiian monk seal—described in Hawaiian as a "dog-like animal that swims in the rough"—which frequents local waters and hauls out on the beaches of several of the Northwestern Hawaiian Islands.

Pihemanu (Midway Atoll) – Along with many of the Northwestern Hawaiian Islands, Pihemanu is a refuge for birds. Its name means "the loud din of birds."

Mokupāpapa (Kure Atoll) – The northwesternmost island in the Hawaiian archipelago may have been called Mokupāpapa. Moku, "islet," combined with pāpapa, "low, flat, expansive reef," means "islet with low-lying reefs." Recorded in chants, the name Mokupāpapa refers to an island or islands of the names description, located northwest of Ni`ihau.

Source: Adapted from: Kimura, L.L. (1998). Hawaiian Names for the Northwestern Hawaiian Islands. In J.O. Juvik & S.P. Juvik (3rd ed). Atlas of Hawai'i (p. 27). Honolulu, HI: University of Hawaii Press.

Historical Timeline of the NWHI

2005 The Northwestern Hawaiian Island Coral Reef Ecosystem Reserve operations' plan is approved

2004 Northwestern Hawaiian Islands Reef Assessment and Monitoring Program (NOWRAMP) conducts additional expeditions to the NWHI to continue collecting data about the NWHI

2002 NOWRAMP conducts expeditions to the NWHI. Scientists map and assess the shallow reefs for biodiversity, status, and management needs

2001 The process to designate the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve as the nation's 14th National Marine sanctuary begins

2000 NOWRAMP expedition is launched as a multi-agency and institutional partnership that brings together the best field resources (people, equipment, and funding) of both the resources trustees (State and Federal) and the academic community

– President Bill Clinton calls for recommendations on the conservation of the NWHI and issues Executive Order 13178, creating the NWHI Coral Reef Ecosystem Reserve, which protects Hawaiian cultural and religious uses

1997 Hui Mālama i Na Kūpuna o Hawai`i Nei re-inters the remains of seven ancient Hawaiians at Nihoa and Mokumanamana

1996 Full jurisdiction and control of Midway Atoll is transferred from the U.S. Navy to the U.S. Department of Interior, U.S. Fish and Wildlife Service, creating Midway Atoll National Wildlife Refuge

1995 – 2000 The Western Pacific Regional Fishery Management Council contractors complete a Review of Coral Reefs around American Flag Pacific Islands, assessing the need and feasibility of establishing a coral reef fishery management plan for the Western Pacific Region

1992 LORAN, a marine navigation system station on Kure Atoll, is closed

1987 – 1991 The Western Pacific Regional Fishery Management Council establishes the Pelagic Fishery Management Plan (1987); NWHI Ho`omalu Zone bottomfish limited entry program (1989); and Protected Species Zone 50 nautical miles around the NWHI, within which longline fishing is prohibited (1991)

1984 A Bishop Museum Expedition finds 25 additional archeological sites on Nihoa and Mokumanamana

1980 – 1986 The Western Pacific Regional Fishery Management Council establishes the Precious Coral Fishery Management Plan (FMP) (1980), Crustaceans FMP (1983), and Bottomfish and Seamount Groundfish FMP (1986)

1978 Following a Governor's Advisory Committee recommendation, the National Marine Fisheries Service, U.S. Fish and Wildlife Service, State of Hawai`i, and University of Hawai`i begin a five-year cooperative research program to identify NWHI marine resources

1965 – 1959 Japanese longliners annually expend up to 2,170 vessel days fishing in the NWHI

1946 – 1959 Nine large commercial vessels fish in the waters of the NWHI

1942 Preparation for possible hostilities led to the development of a U.S. Navy base at Midway Atoll. The Japanese fleet is defeated at the Battle of Midway June 3-6, 1942

1941 On the same day as Pearl Harbor, which starts the U.S. involvement in World War II, Midway is shelled by the Japanese

1923 – 1924 The Tanager Expedition records its travels to a number of islands studying plants, animals, and geology. Kenneth Emory and others on this expedition find 115 archeological sites that include ancient habitation, agriculture, and religious sites. While on Laysan, the expedition witnesses the extinction of the Laysan `apapane (native honeycreeper)

1917 Public officials deny requests to establish a fishing station and cannery at French Frigate Shoals

1909 President Theodore Roosevelt creates the Hawaiian Islands Bird Reservation, a preserve and breeding ground for native birds, which extends from Pearl and Hermes to Nihoa and includes Kure

1908 The rights to remove "products of whatever nature from the islands" of Laysan and Lisianski are given to Genkichi Yamanouchi, who exports tons of feathers and bird wings

1898 The U.S. annexes "the Hawaiian Islands and their dependencies" through a Resolution of Annexation. Most of the NWHI are incorporated into the U.S.

1895 French Frigate Shoals is annexed by the Republic of Hawai`i

1894 Mokumanamana is annexed by the Republic of Hawai`i

1893 The Hawaiian Kingdom is illegally overthrown by a group of American businessmen

1890 The Hawaiian Kingdom allows captains George D. Freeth and Charles N. Spencer to mine guano on Laysan and other NWHI for 20 years, for a royalty of 50 cents per ton

1886 Kure is formally annexed to the Hawaiian Kingdom by King Kalākaua

1885 Lili`uokalani's travel party arrives on Nihoa along with a survey group.

1872 Captain Dowsett of the whaling ship Kamehameha finds Dowsett Reef, just north of Maro Reef, which was found in 1820 by Captain Allen

1859 Captain N.C. Brooks finds the Midway Island while sailing under the Hawaiian flag. He names it Middlebrooks Island (after himself), and claims it for the U.S. under the Guano Act of 1856, a law that authorizes Americans to temporarily occupy unclaimed Pacific islands to obtain guano

1857 Kamehameha IV visits Nihoa and annexes this island to the Hawaiian Kingdom

1828 Laysan Island is found by Captain Stanikowitch of the Russian ship Moller

1823 Captain Benjamin Morrell, Jr. of the schooner Tartar finds Kure Atoll and claims Kure to have an abundance of sea turtles and sea elephants

1822 Ka`ahumanu claims Nihoa as part of Hawai`i. Pearl and Hermes Atoll is accidentally found by foreigners when the ships Pearl and Hermes run aground there

1820 Gardner Pinnacles and Maro Reef are found by Captain Joseph Allen of the brig Maro

1805 Captain Yurii Lisianski runs aground on what becomes known as Lisianski Island

1800 Western sailing ships begin to exploit the area for seals, whales, reef fish, turtles, sharks, birds, pearl oysters, and sea cucumbers

1789 Nihoa is noted by Western explorers. Captain Douglas was among the first Europeans to see the island and named it Bird Island, referring to the multitude of its inhabitants

1786 Captain La Perouse, the first European to sail past Mokumanamana, names it in honor of the French Minister of Finance, Jacques Necker. La Perouse finds the French Frigate Shoals

1779 Captain Cook's men are accompanied by a chief's canoe headed to Ka`ula Island, off the coast of Ni`ihau

1700 Hawaiians from Kaua`i and Ni`ihau make canoe trips to Mokupāpapa, an island west of Ka`ula, for turtles and seabirds

1200 Pele, the Hawaiian Fire-Goddess, and her family arrive in Nihoa

1000 – 1700 Hawaiian habitation on Nihoa and Mokumanana occurs

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Fascinating Facts about the NWHI

General Facts

- The NWHI contain more than 800,000 acres (1,250 square miles) of submerged shoals, coral reefs, and seamounts (that's twice the land surface area of O`ahu).
- The NWHI are home to the healthiest and least-disturbed reefs in the United States. This ecosystem is believed by scientists to be one of the last intact predator-dominated large-scale marine ecosystems in the world.

Midway

- A thriving colony of approximately 500,000 Bonin petrels was almost destroyed by the accidental introduction of rats to Midway in 1943. By 1979, the petrels had declined to 5,000 pairs and had very little nesting success. By 1998, the rats were eliminated and now the petrels' population is growing.
- Midway Atoll is home to the world's largest Laysan albatross colony and the second-largest black-footed albatross colony.
- In February 2002, Chandler S. Robbins returned to Midway Atoll and recaptured a Laysan albatross that he had banded there on December 10, 1956. This bird must have been at least 5 years old when he first banded it (it would have hatched in or before February, 1951). How old would it have been when he recaptured it on its nest on February 5, 2002? Albatrosses live a long time and can raise chicks at advanced ages.

Laysan Island

- Laysan Island was described as a "denuded desert" in the Bishop Museum's Tanager Expedition report in 1929. Scientists described what the island looked like after rabbits multiplied there and ate the native plants.
- The U.S. Fish and Wildlife Service worked hard to restore and maintain this native ecosystem. Now the island has healthy vegetation again and supports the largest number of native birds in the NWHI.
- On a super salty lake lying in the middle of Laysan Island lives the Laysan duck. This, the most endangered species of duck in the United States and the one with the smallest home range of any duck in the world, was found only on Laysan Island until 2004. At that time 20 were relocated to Midway Atoll National Wildlife Refuge, where today they are doing quite well.

French Frigate Shoals

- Only a honu (Hawaiian green sea turtle) knows . . . how to swim back to French Frigate Shoals. A honu tracked by scientists swam from French Frigate Shoals at more than one mile an hour, covering a distance of 702 miles during her 23-day migration to Kāne`ohe Bay on O`ahu!
- When turtles are mature adults (around 20 to 25 years old), they return to the same place they were hatched to lay their eggs. An estimated 800 female green sea turtles nested at French Frigate Shoals during 2002. Each female can make three nests holding an average of 100 eggs per nest. How many eggs were laid during 2002?
- Nine out of every 10 turtles seen in the main Hawaiian Islands were hatched within the protected French Frigate Shoals atoll.

Unbelievable Flights!

- Sooty terns NEVER sit on the water! After leaving their nests, they fly at sea for at least a year before touching land!
- An albatross is an amazingly efficient long-distance flyer. Using its wings like a glider plane, it can fly 62 miles per hour! Albatross have 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.

Monk Seals

- Monk seals have existed for 15 million years with virtually no evolutionary changes. This earns them the title “living fossils.”
- Monk seals are one of only two mammals native to Hawai`i. Do you know what the other native mammal is? (Hawaiian hoary bat)
- Seeing a monk seal pup was once an extremely rare occurrence. Over the last 7 years on Midway Atoll, there has been much less human disturbance to the seals. Recently, a record 15 monk seal pups were born on the atoll.

Home Sweet Home

- Seventy-two terrestrial arthropods, including species of giant cricket and giant earwig, three plant species, and two land birds (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 and Gardner Pinnacles. These two islands have native plant communities and no invasive species! This provides excellent habitat for hundreds of thousands of nesting native birds.
- Established in 1909, the Hawaiian Islands National Wildlife Refuge encompasses the islands and reefs stretching 800 miles from Nihoa to Pearl and Hermes Reef.
- 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 with 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. Nests for 12 of these species can be found on the island’s steep cliffs.

- Black-lipped pearl oysters were once so common at Pearl and Hermes Atoll that an entire button industry was created to produce pearl shell buttons. Due to over harvesting, the species almost disappeared from Hawai`i. The Territory of Hawai`i made it illegal to harvest these oysters in 1929, but the species has never recovered.

Personal Stories of Nihoa and Necker Islands

By Dennis Kawaharada

In 1822, Ka`ahumanu and a royal party including Kaumuali`i, Liholiho, Keopuokalani, and Kahekili Ke`eaumoku visited Ni`ihau and heard chants and stories about an island called Nihoa to the west of Kaua`i, the direction from which the winter rains came:

> `Ea mai ana ke ao ua o Kona,
> `Ea mai ana ma Nihoa
> Ma ka mole mai o Lehua
> Ua iho a pulu ke kahakai
>
> The rain clouds of Kona come,
> Approaching from Nihoa,
> From the base of Lehua,
> Pouring down, drenching the coast.

Intrigued, Ka`ahumanu organized an expedition and sailed in two or three boats under Captain William Sumner to visit the island. They landed on the once inhabited but long deserted island 150 miles WNW of Kaua`i, and annexed it to the Hawaiian Kingdom. The waterfront area around Ka`ahumanu Street in Honolulu was named Nihoa in honor of the visit. The island was annexed to the Hawaiian Kingdom again by Kamehameha IV, who landed on the island in 1857. In 1885, Queen Lili`uokalani, with 200 excursionists, visited Nihoa on the steamer `Iwalani, and brought back artifacts—a stone bowl, a stone dish, a coral rubbing stone, and a coral file (Emory 8-11).

Nihoa, jutting up from the sea beyond sight of Kaua`i and Ni`ihau, is the westernmost place in this tradition of Kaua`i geography. It has come to stand for "one who bravely faces misfortune": "Kū paku ka pali o Nihoa i ka makani." The cliffs of Nihoa stand strongly against the wind (Pukui, `Ōlelo No`eau #1924). "Nihoa" means "firmly set," or "toothed, serrated," possibly a reference to its jagged profile—from one side it looks like a molar, standing isolated at sea. (In Micronesia, an island seen from a departing canoe just before the island disappears from sight is called a "tooth," and serves as a final landmark to orient the canoe on its voyage.)

Nihoa is one mile long, a quarter of a mile wide, and 900 feet high on its east end. It was designated as part of a wildlife refuge by Theodore Roosevelt in 1909. It is inhabited by insects; monk seals; two species of land birds, a finch and a millerbird, found nowhere else; and numerous seabirds (terns, boobies, petrels, shearwaters, albatrosses, tropic birds, and frigate birds). Today, access is controlled by the U.S. Fish and Wildlife Service, and landing, except for scientific study and cultural purposes, is prohibited.

Nihoa was once inhabited by the kānaka maoli, sometime between 1000 and 1500 A.D. About 35 house sites, 15 bluff shelters, 15 heiau, and 28 agricultural terraces have been identified on the island (Emory 12; Cleghorn 21-22). Various artifacts have also been collected, including fishhooks, sinkers, cowry shell lures, hammerstones, grindstones, adzes, and coral rubbing stones (Emory 38-50). The evidence seems to indicate permanent or semi-permanent settlement. Living on the island would have been difficult. Surveys have discovered only three seeps of water, all contaminated with guano (Emory 12). Tava and Keale report a tradition of Ni`ihau that a spring called Waiakanohoaka provided good, sweet water (102), but this spring has not been located. The freshwater on the island comes from the estimated 20-30 inches of rain that falls annually from passing squalls (Cleghorn 26).

Archaeologists surmise that the terraces were planted with sweet potatoes, a crop requiring less water than thirsty taro. They estimate that the 12-16 acres under cultivation might have supported about 100 people (Cleghorn 25). Fish, shellfish, crabs, lobsters, turtles, and seals, as well as seabirds and their eggs, are abundant sources of food. Cleghorn speculates that the food and water supply was sufficient for subsistence, but that the lack of firewood would have created a hardship (26). The only tree on the island is the loulu palm. Research expedition members counted 515 palms in 1923. The fan-like leaves were used for plaiting, and the trunks could have been used for building shelters or for firewood. But if the trees were cut down for firewood, the supply would have eventually been depleted.

Without the numerous kinds of plants found in the forests of the larger islands (e.g., koa, `ōhi`a, hau, hala, olonā, wauke), the settlers could not have provided themselves with canoes, wood containers, nets, fishing line, clothing and blankets, mats, and medicines. The colony was probably supplied with these products from Kaua`i or Ni`ihau. Several gourd fragments have been found; other bowls and containers were carved from stone.

Landing on the island is difficult. High, sheer cliffs prevent landing on the east, north, and west sides. The island slopes down to the south, but the shoreline is rocky and unprotected from the surge of southerly swells. Large vessels anchor offshore, and those who wish to land have to go in on a smaller boat or swim ashore. In ancient times, small canoes could have been carried up onto the rocky coast on calm days. If the canoes used to reach the island were somehow damaged in the rough surf, the settlers would not have been able to repair them with resources from the island. They would have been trapped until other canoes arrived from Ni`ihau or Kaua`i.

Partial skeletons of men, women, and children have been found on the island, and two burial sites located. The journey of spirits to the afterworld (in the west, toward the setting sun) would have been shorter from this western outpost than from the islands to the east. The name of a place on the island where spirits of the dead departed for the afterworld is still remembered: It was called Mau-loku ("Continuous falling"; Pukui et al, Place Names of Hawai`i).

How the island was discovered is not known—possibly by fisherman working the seas west of Kaua`i or following seabirds to gather their feathers or eggs. Red feathers were coveted for making sacred objects, and the red-tailed tropicbird is one of the seabirds that nests on Nihoa. Polynesians traveled great distances to obtain such feathers: One Marquesan tradition tells of a 1200-mile voyage, from Hiva Oa to Rarotonga, to obtain the red feathers of a kura bird; and the voyaging chief Hema is said to have sailed back to Kahiki to obtain a girdle of red feathers for his son Kaha`i.

Once discovered, the island became a part of the economy of Ni`ihau, an island relatively limited in resources. The traditions of Ni`ihau say that the people of that island were frequent and perhaps long-term visitors to collect loulu palm wood for spears and a grass called makiukiu, which could be used for cordage and stuffing (Tava and Keale 102).

Another motive for visiting the island is suggested by the chant of Ni`ihau describing the Kona rain clouds coming from Nihoa and soaking the west coasts of Kaua`i and N`ihau. Small, low islands like Ni`ihau, and the leeward coasts of high islands like Kaua`i, depend on the heavy rains of annual Kona storms to bring life to their crops. But if the storms stay west or pass to the north without reaching Hawai`i, droughts and, in ancient times, famine could occur. Could the people of Ni`ihau or leeward Kaua`i have sailed west to get closer to the source of these rain clouds, or to the deities who controlled them, in order to pray for rain and make offerings? Water represented life and wealth in ancient Hawai`i, and such a voyage might have been worth the effort and the risk.

One hundred and fifty miles west of Nihoa is an island called Necker. This island is smaller and has even fewer resources than Nihoa. There are no trees and is no soil. Yet the island is covered with some 33 heiau (Emory 59). Several stone images, the largest around 16 inches high, were found by visitors in historical times. The images look like gingerbread men—flat, neckless, with round faces from which eyes, noses, mouths, and ears protrude (Emory 125, Illustrations XX-XXII). Who or what these images represent is unknown.

The Hawaiian name for Necker has been lost. But Teva reports that there are four names remembered on Ni`ihau of islands beyond Nihoa: Mokuakamohoali`i, Hanakaieie, Hanakeaumoe, and Ununui (103). Mokuakamohoali`i, "Island of the Shark God Kamohoali`i," is a possible name for Necker, as the largest geographical feature on this island is a bay called Shark Bay. Kamohoali`i was the king of sharks and brother of the volcano goddess Pele. The Pele migration is said to have come from the west, with Kamohoali`i serving as navigator.

Cleghorn suggests that in addition to going to Necker for gathering resources such as bird feathers and eggs, the visits may have had a ritualistic purpose: The heiau could have belonged to a bird cult, similar to the one on Rapa Nui (Easter Island) (61). But the heiau and statues could also have been used in rain-god worship. As in the Hopi kachina rituals in the American Southwest, the rain deities might have been associated with ancestral spirits who return each year in the form of rain clouds from their homes in the west. (The winter rains of the American Southwest come from the west, as they do in Hawai`i.) In either case, birds and rain clouds are metaphorically connected with each other in Hawaiian chants. Beckwith notes, "The cloud hanging over Ka`ula is a bird which flies before the wind:

The blackbird begged,
The bird of Ka`ula begged,
Floating up there above Wa`ahila"
(The Hawaiian Romance of Laieikawai, p. 323).

Nihoa would have been a stop on the way to or from Necker. Annual visits to Necker during the spring and summer trade wind season could have been made, when food would have been abundant on and around Nihoa and Necker. A Ni`ihau tradition suggests such was the case: "The Ni`ihauans sailed to Nihoa in the spring, returning to Ni`ihau in the fall on the Kona winds" (Tava and Keale 102). The same sailing strategy could have taken them to Necker. After landing on Necker, prayers and offerings could have been presented to the deities. Then the pilgrims could have fished, hunted birds, collected eggs, and built or maintained heiau. When a cold front approached, the canoes could have headed back to Ni`ihau or Kaua`i on the southwesterly winds that preceded the front, or the northerly winds that followed.

Any downwind sail with the prevailing winds is a risky undertaking, because unless the wind shifts, the sail home involves tacking into the wind, something which the keel-less Polynesian canoes would have great difficulty doing. The risk is weighed against the importance of the potential benefits of going to the downwind destination. For a community dependent on farming, drought could be disastrous. If one of the sources of the life-giving waters of Kāne was westward, was it worthwhile to sail west to present offerings and prayers to a god who brought life-giving waters? For a time in Hawaiian prehistory, the answer was apparently yes; then, perhaps after dry-land taro and sweet potato cultivation in areas with limited rainfall had improved enough so that famine was no longer a seasonal threat, such voyages became unnecessary.

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Northwest Islands Dotted with Wrecks of Old Vessels

Posted on Monday, June 7, 2004 – Honolulu Advertiser Special
By Jan TenBruggencate - Advertiser Science Writer

LAYSAN ISLAND, French Frigate Shoals –Hōkūle`a's crew, hauling hundreds of pounds of marine debris from Laysan's beaches, repeatedly trudged through soft sand by the rusted bow and flaking machinery of a wrecked steel fishing boat. It is just one of the dozens of crafts that have come to their ends on Hawai`i's leeward islands, which stretch like a vast rock and coral trap 1,200 miles from Kaua`i to Kure Atoll. The wrecks still happen every few years. In recent decades the victims have mainly been fishing boats, but decades and centuries past they were coal carriers, sail-powered whalers, military ships, tankers, pleasure craft, and many more.

Many had survivors, who reported the wrecks. Many more, it is assumed, did not. There is still a lot of surveying to do, but even among those areas that have been swept for lost ships, there are mystery wrecks, said marine archaeologists Hans Van Tilburg, maritime heritage coordinator for the Pacific Islands Regional Office of the National Oceanic and Atmospheric Administration's National Marine Sanctuary Program. It's even possible that Spanish treasure galleons filled with Mexican silver wrecked here. Spanish ships crossed from Acapulco to Manila once or twice a year from about 1565 to 1810, he said.

Van Tilburg was interviewed before Hōkūle`a started its voyage through the islands. One problem in identifying old wrecks is that islands are subject to huge storms, powerful seas, and occasional tsunami, and old wooden ships would have left little evidence behind. "That's a high-energy environment," Van Tilburg said. The rough seas, tricky currents, difficult-to-spot shoals and reefs, and narrow passages are among the reasons why Hōkūle`a's captain, Nainoa Thompson, abandoned non-instrument navigation once passing the volcanic islands of Nihoa and Mokumanamana and entering a region with an 800-mile stretch of reefs, shoals, and banks. Before approaching any low island he pours over maritime charts and often keeps two global positioning system satellite navigation units running at once—each as a check for the other. "It's too risky, too dangerous" to take lightly, he said.

The canoe sailed up to Lisianski Island yesterday morning, but anchored three miles from shore. Coral heads and reefs, many of which are poorly charted, surround the island. The crew dived on the reef for half an hour, then raised anchor and sailed for Pearl and Hermes Atoll, which it expected to reach this morning. Although he said the coral and marine life are remarkable there, he opted to sail by Maro Reef entirely. Many wrecks would appear to justify his caution.

There are wrecks that could be serious threats to the environment, like the 1957 loss on Maro Reef of the Navy oil tanker Mission San Miguel. It was not carrying a cargo of oil when it went down, but would still have had a lot of residual oil in its tanks, plus its own fuel oil and other fluids. When the Navy tried to salvage it, there was too much oil in the water for divers to work and the salvage was abandoned. And when folks returned to the site later, the ship was gone. "It had been high on the reef, hard aground, and then there was no trace of it anymore. We assume it launched itself into the deep," Van Tilburg said. One fear is that some of its tanks are still whole but deteriorating, and that they will ultimately fail and cause a major oil spill. "The topic worldwide is an important one. The Navy could pump it out if it is shallow enough. It would be nice to confirm its location in case it starts leaking," he said. The captain of the three-masted copra schooner O.M. Kellogg, which wrecked on Maro in 1915 while bound from Samoa to San Francisco, complained a month later in the Honolulu

Advertiser that "I think it is always bad weather at Maro Reef." And as Hōkūle`a sailed by south of the reef last week, there were dark rain squalls on Maro.

The most important known marine archeological find in the Northwestern Hawaiian Islands is probably the 1870 wreck of the USS Saginaw at Kure Atoll, Van Tilburg said. He and a crew of divers in August 2003 found remains from the Navy ship, including two small iron cannons, iron anchors, metal rudder fittings, and copper pins that once held the major timbers together. The Saginaw had been sent to nearby Midway to blast a channel, so a coal fueling station could be established there. The ship had been built during a period when sail power was giving way to steam. It was a hybrid: a coal-fired, steam-powered side-wheeler that carried masts and salts. All 93 men aboard survived the wreck, and lived on Green Island, a flat sand and coral islet just inside the reef. Five of the crew sailed a small boat for help. They made it 1,200 miles to Kaua`i, but they were extremely weak by then. Four died while landing in the rough surf. The crewmembers who remained on Kure, eating seal and albatross meat and drinking rainwater, all survived.

Van Tilburg said he would love to do more work on the wreck, including trying to find the remains of the survivors' camp to see what can be learned about how they lived. Shipwreck survivors need to be innovative, because they often have few resources. Survivors of the 1842 wreck of the whale ship Parker at Kure used pieces of copper from their own wreck or the previous wreck of the ship Gledstanes to make cooking utensils. Wrecks were such a common occurrence that the crew of one rescue ship in 1886 planted trees and built two 500-gallon water tanks with a raingutter system to aid future victims on Kure. But vandals from other ships had destroyed the improvements within a year.

Photo by Polynesian Voyaging Society

Advertiser Science Writer Jan TenBruggencate is sailing as a crewmember aboard the voyaging canoe Hōkūle`a as it sails through the Northwestern Hawaiian Islands. His dispatches are sent back via satellite phone.

Source: http://the.honoluluadvertiser.com/article/2004/Jun/07/ln/ln10a.html

Shipwrecks at Pearl and Hermes Atoll

Posted by Dr. Hans Van Tilburg
Maritime Archeology and History Team Leader
September 28, 2002

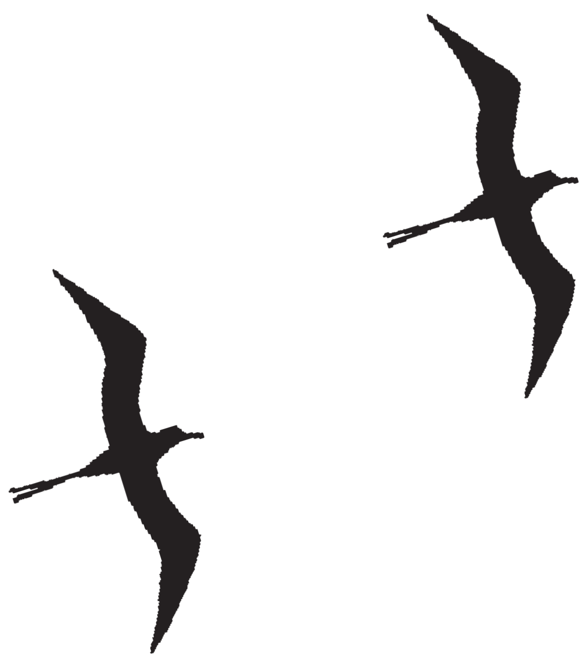
Unfortunately, the USS Saginaw at Kure eluded our efforts. We did a number of diver tow searches in the area indicated by historic references, but saw no traces of the wreck. Sedimentation rates on that side of the atoll are high, and it's possible that after 132 years, the material is buried deep under the sands.

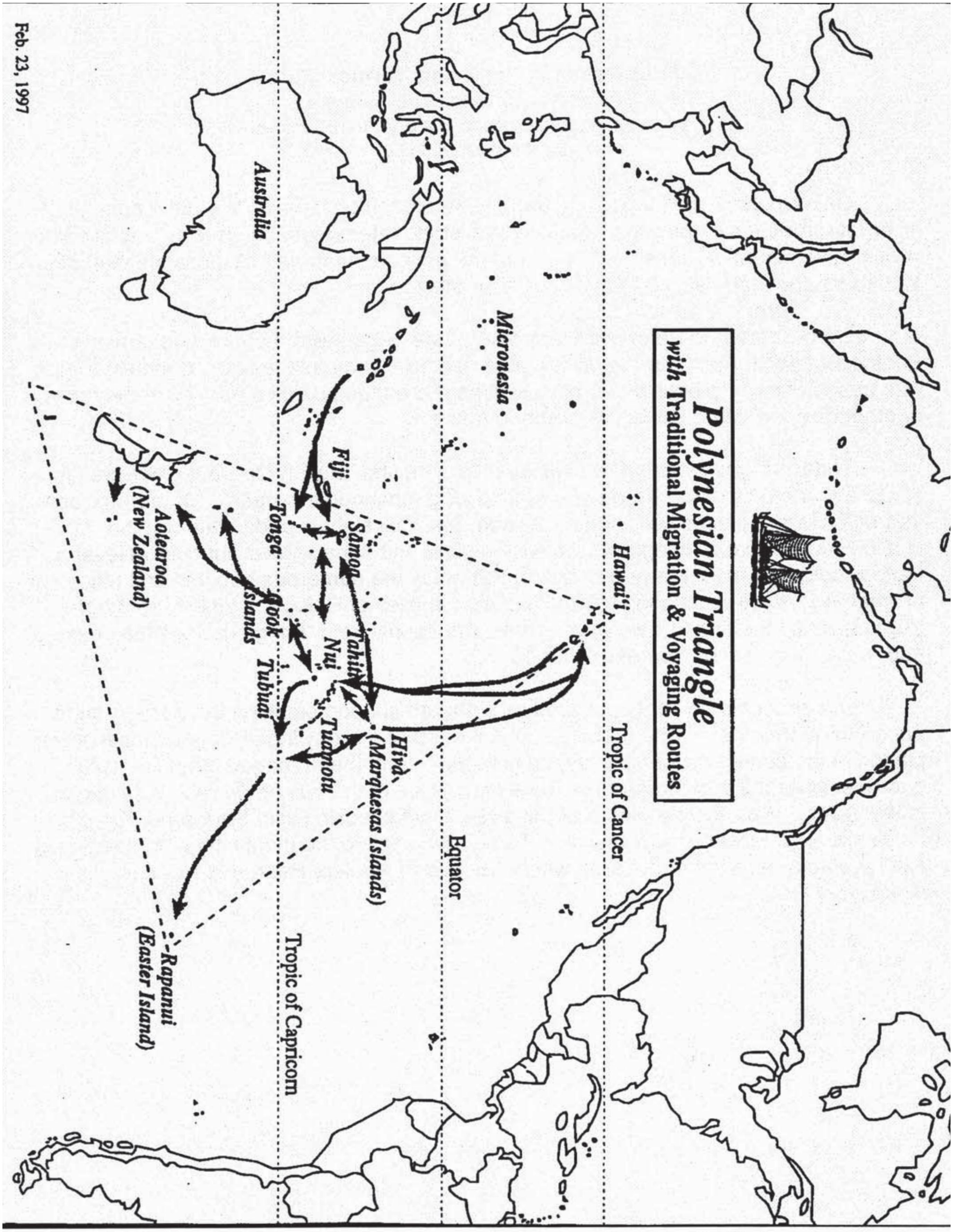
On our return to Pearl and Hermes Atoll we began with a shore side survey of Southeast Island. Again, traces of cut giant bamboo, some pieces over 6 meters long, with traces of cross pieces and lashings. Where are these coming from? Are they rafts or other devices? Who still builds bamboo rafts?

Today's dives included two wreck sites. The first, the SS Quartette, wrecked in 1952. The remains of the Korea-bound ship long remained emergent, but are now only four or five small pieces occasionally awash. The real sight is underwater on the shallow reef, where a topography of twisted steel and ruins spread out over at least a football field size area. Many varieties of fish enjoy the numerous habitats and refuges of what used to be, according to Mark Rauzon in Isles of Refuge, a Liberty ship from World War II. Liberty ships were, of course, the supply train "bridge" across the oceans, and many found second careers after 1945.

Our second dive spot appeared as a square-shaped block on the horizon far to the north on the edge of the reef crest. It is the top of a six-cylinder marine diesel power plant. On the coral spires below lay the propeller shaft, the damaged propeller itself, and twisted debris and machinery. There is no trace of the hull or the rest of the wreck in the vicinity. We have no record of this vessel, but checking with the Coast Guard on our return might clear up this mystery. Tomorrow, back to the most intriguing needles in the haystack . . . a return to the area where the British whalers Pearl and Hermes wrecked in 1822.

Source: http://www.hawaiianatolls.org/research/NOWRAMP2002/journals/pahwrecks.p





______. (2003). *Teacher Information Packet. Navigating Change*. An Exhibit on the Northwestern Hawaiian Islands at the Hawai'i Maritime Center. Honolulu, HI: Bishop Museum & NASA.

Sea and Land Birds Nesting in the NWHI

Black noddy (Oio)

Black-footed albatross

Blue noddy

Bonin petrel

Brown booby (`Ā)

Brown noddy (Noio koha)

Bulwer's petrel (`Ou)

Christmas shearwater

Dark-rumped petrel (`Ua`u)

Gray-backed tern (Pākalakala)

Great frigatebird (`Iwa)

Laysan albatross (Mōlī)

Laysan duck

Laysan finch

Little tern

Masked booby

Newell's shearwater (`A`o)

Nihoa finch

Nihoa millerbird

Red-footed booby (`Ā)

Red-tailed tropicbird (Koa`e `ula)

Short-tailed albatross

Sooty Tern (`Ewa`ewa)

Tristram storm petrel

Wedge-tailed shearwater (`Ua`u kani)

White or Fairy Tern (Manu o Kū)

White-tailed tropicbird (Koa`e kea)

Marine Organisms of the NWHI

Shallow Reef Organisms

Antler coral (Ko`a)

Arc-eye hawkfish (Pili ko`a)

Banded coral shrimp (`Ōpae kai)

Black sea cucumber (Loli)

Black triggerfish (Humuhumu`ele`ele)

Bird wrasse (Hinalea`i`iwi)

Blue coral (Ko`a)

Cauliflower coral (Ko`a)

Christmas wrasse (`Āwela)

Cleaner shrimp (`Ōpae)

Coralline algae (Manamana`ula)

Hawaiian cleaner wrasse

Hawaiian hogfish (`A`awa)

Hawaiian whitespotted toby

Hermit crab (Unauna)

Limpets (`Opihi)

Linckia seastar

Manybar goatfish (Moana)

Nerite snail (Kūpe`e)

Orange tube coral (Ko`a)

Ornate butterflyfish (Kīkākapu)

Oval chromis

Periwinkle snail (Pūpū kōlea)

Reticulated brittlestar (Pe`a)

Rock-boring urchin (`Ina Uli)

Saddle wrasse (Hinalea lauwili)

Sea lettuce (Limu palahala)

Slate pencil urchin (Ha`uke`uke`ula`ula)

Slipper lobster (Ulā papapa)

Spotted boxfish (Moa)

Tiger cowry (Leho)

Triton's trumpet (Pū)

Yellowfin goatfish (Weke)

Yellow margin moray eel (Pūhi paka)

Yellowtail coris (Hīnālea `Aki lolo)

Mid Reef Organisms

Bluefin trevally (`Ōmilu)

Convict tang (Manini)

Fire dartfish

Giant trevally (Ulua aukea)

Goldring surgeonfish (Kole)

Gray reef shark (Manō)

Hawaiian anthias

Hawaiian dascyllus (Alo`ilo`i)

Hawaiian sergeant (Mamo)

Hawaiian squirrelfish (`Ala`ihi)

Leatherback (Lai)

Lobe Coral (Ko`a)

Longnose butterflyfish (Lauwiliwili nukunuku`oi`oi)

Long-spined urchin (Wana)

Milletseed butterflyfish (Lauwiliwili)

Moorish idol (Kihikihi)

Octopus (He`e mauli)

Orangeband surgeonfish (Na`ena`e)

Orangespine unicornfish (Umaumalei)

Peacock razorfish (Laenihi)

Pennant butterflyfish

Potter's angelfish (`Ānela i`a)

Raccoon butterflyfish (Kīkākapu)

Reef triggerfish (Humuhumunukunukuāpua`a)

Spotted eagle ray (Lupe)

Spotted pufferfish (`O`opu hue)

Trumpetfish (Nūnū)

Whitemargin unicornfish (Kala kea)

Whitetip reef shark (Manō lālākea)

Yellow tang (Lau`ī pala)

Open Ocean Organisms

Amberjack (Kāhala)

Dolphinfish (Mahimahi)

Hawaiian stingray (Hihimanu)

Humpback whale (Koholā)

Mackeral scad (`Ōpelu)

Marlin

Ono

Oceanic whitetip shark (Manō)

Portuguese man-o-war (Pa`imalau)

Short-winged flying fish (Mā lolo)

Smalltail stingray

Tiger shark (Manō)

Yellowfin tuna (`Ahi)

Source: ______. (2003). Education Kit: Navigating Change Northwestern Hawaiian Islands. Hawai`i: PREL, NOAA, State of Hawai`i Department of Education, U.S. Fish and Wildlife Service, Department of Land and Natural Resources & Bishop Museum

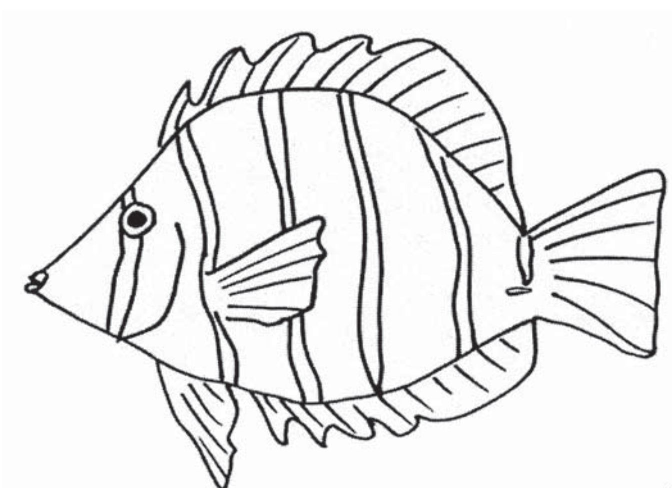
Pop-up Reef

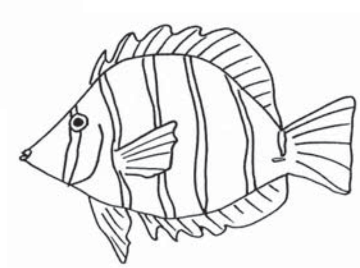
Materials Needed

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

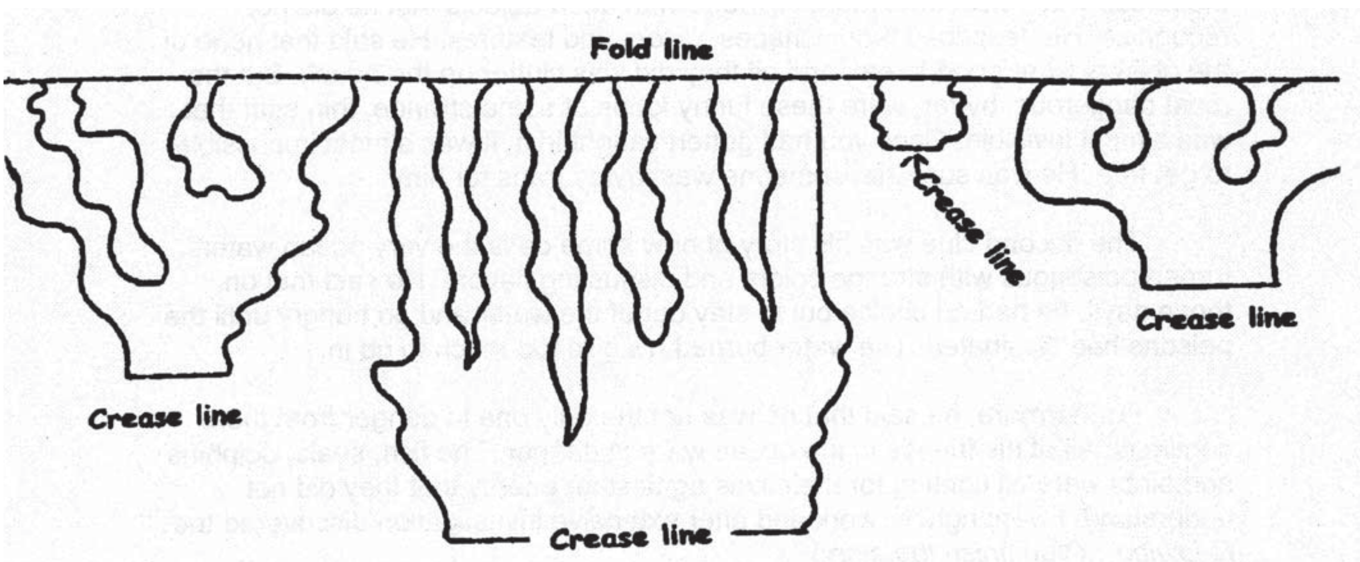
Directions

- 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-dimensional reef.
- Glue the flat unpopped parts of the reef to another piece of construction paper.
- Create reef critters and algae and add them to the popped-out reef.





Source: (2003). Education Kit. Navigating Change: Northwestern Hawaiian Islands. Hawaii: PREL, State of Hawaii Department of Education, Department of Land and Natural Resources, NOAA, U.S. Fish and Wildlife Service, and Bishop Museum.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Crease line
Crease line
Crease line
Crease line

The Case of Claud the Crab — Student Reading

Your job is to solve the problems of Claud the Crab. Read the story below. Write your own story about what you, the Detective, were 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 Claud the Crab, and told me he desperately needed to hire a private detective. Of course, my first question was what crime was it that he needed investigated. He started talking very fast and clicking his claws together in obvious panic. When I could finally get him calmed down enough that 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! Yet he did not have any idea of what was going on or why someone would want to kill him. Claud 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 the many shapes, colors, and textures he saw. 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 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 these 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 they did not understand—or even see! I went right to work and after extensive investigation discovered the following. . . . (You finish the story.)

Source:______. (2003). Education Kit: Navigating Change Northwestern Hawaiian Islands. Hawai'i: PREL, NOAA, State of Hawai'i Department of Education, U.S. Fish and Wildlife Service, Department of Land and Natural Resources & Bishop Museum.

Questions

1. What impacts can coastal communities have on reefs?
2. How does marine debris affect animal life?
3. How do introduced species affect the native animals in the ocean?
4. How do fishing vessels that have gone ashore 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 replace vegetation with bare soil and concrete also increase the runoff of freshwater and sediment into coastal waters. Reef-building corals have a low tolerance for unnatural runoff and sediment deposits.

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 they must be done with care. Overharvesting 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 along our coasts. Divers and snorkelers 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 1950s several species of snappers and groupers were brought here and released on the reefs. Two of these (tghe blue-lined snapper and argus grouper) are now abundant and competing with native fish. Non-native aquarium fish and invertebrates have also been released by people. These 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 arrive here by accident in the ballast water of ocean-going ships. Several species of algae, mollusks, and 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 Hawaiian Islands.

Source:_______. (2003). Education Kit: Navigating Change Northwestern Hawaiian Islands. Hawai'i: PREL, NOAA, State of Hawai'i Department of Education, U.S. Fish and Wildlife Service, Department of Land and Natural Resources & Bishop Museum.

Marine Debris Proves to Be Real Threat to Voyage

Posted on Tuesday, June 8, 2004 – Honolulu Advertiser Special
By Jan TenBruggencate – Advertiser Science Writer

PEARL AND HERMES ATOLL, Northwestern Hawaiian Islands – The voyaging canoe Hōkūle`a sailed to an anchorage for a brief stop here yesterday morning, but during the middle of the previous night it had not been clear the canoe would make it.

A little after 11 p.m., the crew of the escort boat Kama Hele reported "a problem with the engine." The problem: It had stopped abruptly. Engineer Steve Garrett at first suspected a transmission problem. Someone finally jumped into the water and diagnosed the problem: A twisted mess of drifting ropes had wrapped around the single propeller—another threat of marine debris. Near midnight, with no moon and with the dark, deep ocean below, crewmen Kiyoshi Amimoto and Tim Gilliom went over the side with lights and knives. Hōkūle`a took down its sails and drifted in wait two miles ahead. The two cut through rope after rope, stopping occasionally to scan the waters around them with lights for predators. They got the prop free, and by midnight both Kama Hele and Hōkūle`a were again under way. Hōkūle`a's crew applauded Amimoto and Gilliom when the two boats anchored at Pearl and Hermes.

Shortly after dawn, the canoe had its biggest day of fishing to date. Four handlines were trolling behind the vessel. Suddenly one hit, then another, and as they were being hauled in, a third, and then a fourth. The crew hauled in two kawakawa and two small `ahi. One of the lines was fed back out to aid in untangling it, and another fish hit, got loose, hit again, got loose again and then hit hard a third time. It was another small `ahi. The crew had fish chowder and teriyaki fried fish on Sunday night with that day's catch, made by sailing master Bruce Blankenfeld. Yesterday, Russell Amimoto and Tava Taupa made a heaping platter of sashimi and fried fish at lunch, and the crew was arguing over whether to have `ahi spaghetti or more sashimi for dinner. The sashimi was served on cabbage. The canoe's cabbages were still usable, but only after several layers of blackened and rotten leaves are removed from the outside, and black spots cut out of the inside.

The only fruits left are shriveled lemons and limes. Onions are OK. Potatoes are soft and turning green. Squashes and sweet potatoes still look good, but haven't been tried. The canoe has done well with eggs. The voyage is into its third week without refrigeration, and each egg is float tested—if it sinks it's deemed OK. If it floats, it's assumed to be bad. As of yesterday, all eggs had been good. "Last voyage, they lasted 27 days," said watch captain Russell Amimoto, the younger brother of Kiyoshi Amimoto, who helped clear the escort boat's propeller.

The ship's doctor, Cherie Shehata, has been busy with one or more medical issues daily. Captain Nainoa Thompson appears to be doing well after injuring his ribs a week ago off French Frigate Shoals, although he had some soreness after snorkeling yesterday. Shehata has also stitched a gashed finger, taped a possible broken toe, worked on a jellyfish sting, dealt with seasickness, and responded to leg rashes and abrasions. She's a triple treat who also works the sails and steers, and in recent mornings has cooked crew breakfasts.

Pearl and Hermes is the second-largest atoll in the Hawaiian archipelago. These low coral islands are difficult to spot, even though we were using satellite navigation techniques and knew where Pearl and Hermes Atoll was. Three miles from it we could see no sign of it. At about two miles, from the deck of Hōkūle`a, an occasional spot of white on the horizon suggested surf breaking on the reef and at 1.6 miles we could pick out a narrow line of cream-colored sand, distinct from the bright white of the surf. It was Southeast Island, the largest of the sandbars here. We'd been looking for the green clouds we'd seen at French

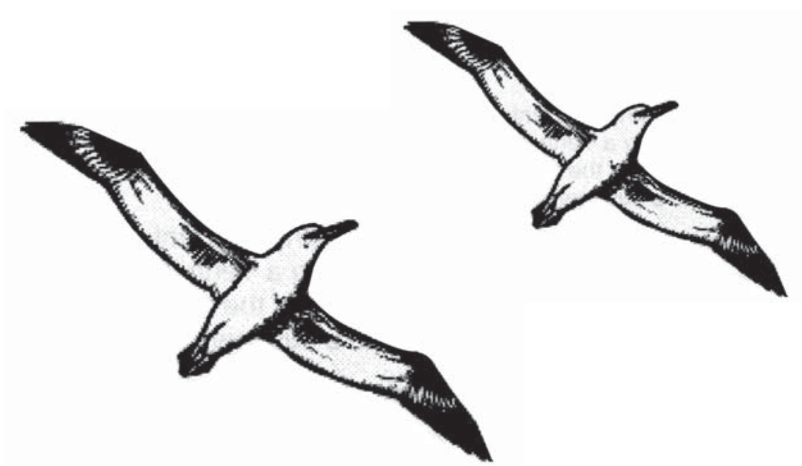
Frigate Shoals—white clouds that turn chartreuse from the reflection of the shallow lagoon water. We didn't see them on our approach, because there weren't any low clouds at all over the lagoon—although we spotted the green wonders later.

Next, we could pick out the hump of swells, rising up before they broke on the fringing reef, and then we could see a line of pale bluish green on top of white breakers. It was the inside of the lagoon. Sooty terns came screeching by, and we spotted a turtle swimming. The water under the boat was getting paler as it shallowed. About a third of a mile out, we could pick out the steady roar of the breakers. The sand island we were approaching grew thicker with closeness, and what at first looked like greenery on its 10-foot highest point turned out to be a cluster of green tents occupied by a NOAA Fisheries seal-monitoring team. There isn't much land vegetation on Pearl and Hermes.

A few hundred yards off the reef, we could pick up detail. We could see the pale blue patches of sandy bottom on the outside of the reef, the pale green shallower sandy patches inside, and the darker green areas inside where coral and algae reefs were. Beyond that, there was the darker blue water of the deeper areas inside the lagoon.

After our brief diving stop, we sailed on for Kure Atoll, the end of the Hawaiian Archipelago. We hoped to walk on Green Island there and dive its reefs before sailing to Midway, where this crew will leave the canoe and a new crew is waiting to take Hōkūle`a back home.

Advertiser Science Writer Jan TenBruggencate is serving as a crewmember on Hōkūle`a as it sails through the 1,200 miles of the Northwestern Hawaiian Islands. His dispatches are sent back via satellite telephone.



Source: http://the.honoluluadvertiser.com/article/2004/Jun/08/ln/ln15a.html

Good Seeds

Pearl and Hermes Atoll
– September 29, 2002
Posted by Kaliko Amona, Graduate Intern
NWHI Coral Reef Ecosystem Reserve

At so many of the islands we've visited during this expedition, our teams have been extremely cautious with our clothes, shoes, and equipment, not wanting to introduce any alien plants or animals to these pristine environments. Today we were just as careful, wearing only new clothing that had been sealed and frozen for 48 hours before we left Honolulu, but there was one difference. At Pearl and Hermes Atoll, our goal was to bring seeds, the good kind, from one island to another.

At North Island, our group split up into teams to work on the day's first order of business—counting birds. Watching first for their burrows, then for nohu (Tribulus cistoideds) barbs, Ethan and I carefully walked the island looking for noio (brown noddy) and `iwa (great frigate bird) chicks and eggs. Most of the young noio we found were hidden in the shade of Eragrostis variabilis grass, quietly waiting for a parent to arrive with their daily meal. Beneath the roots of this grass we peeked into burrows where wedge-tailed shearwaters did the same.

After the bird count, we collected seeds from the Eragrotis to plant at Southeastern Island. Native to Pearl and Hermes Atoll, this bunch grass-like plant provides excellent habitat for many of the seabirds that live here. The native plants at Southeastern Island have not fared as well as those on North Island, with Verbesina (golden crown-beard) and other alien plants taking over some parts of the island. Verbesina is the same alien plant that we fought during our stay on Green Island at Kure Atoll. Verbesina appears to be an allelopathic plant—it may release chemicals that prevent other plants from growing around it, so it easily out-competes many native plants. As part of its annual cycle, the Verbesina dies back, leaving barren areas with very little vegetation. These barren areas provide unstable soil for burrowing birds and their burrows may easily collapse if the soil becomes wet. To help the birds, and the entire ecosystem, we scattered native Eragrotis seeds over an area that the terrestrial crew had cleared of pest plants earlier in the week.

In all, we sowed about a gallon and a half of the tiny Eragrostis seeds. A year ago, Alex Wegmann of the U.S. Fish and Wildlife Service scattered a little less than this amount and twelve plants have come up since. Our efforts today are a small step toward restoring Southeastern Island. It will take much more work, but the U.S. Fish and Wildlife Service's work at Laysan Island provides evidence that such restoration is possible. Over several years, field crews there have transformed the island environment from one that was degraded by human exploitation to an ecosystem where native plants and animals thrive.

Footnotes:

During our search we came upon a koa`e`ula (red-tailed tropic bird) chick sitting under the shade of Eragrostis. Although we were focusing on noio and `iwa for the count, we made a note of this one and continued on. Only after returning to the rest of the group did we find out what a special find we had made. Beth Flint, our escort from the U.S. Fish and Wildlife Service, told Ethan and me that this was the only red-tailed tropic bird chick reported during their surveys during the past several days. By now, most koa`e`ula have fledged and are out on their own.

We also gathered seeds from the native Solanum nelsoni plants we came across on North Island and sowed them on Southeast Island. The large black fruits are filled with small, chili pepper-like seeds.

References:

Beth Flint and Alex Wegmann, U.S. Fish and Wildlife Service

Efforts to Mālama the NWHI

The incredible life that still flourishes in the NWHI is a product of not only the area's remote location, but also of visionary management that began almost 100 years ago, when early protections were put in place. Before the region became a wildlife refuge, Laysan Island, for example, was mined for eggs, bird feathers, and guano, leading to the death of hundreds of thousands of Laysan albatross. Today, the island's habitat and its bird population are being restored. These efforts continue as many more of the island ecosystems impacted by human occupation and introduction of alien species are restored to their natural state. Protections afforded to land and shallow waters have been extended to deeper waters surrounding the islands in recognition of the connections between land and sea, and particularly to protect endangered species and some of the last truly wild coral reefs on the planet.

Scientists, on annual research cruises to the region, continue to discover new marine species. They also collect data on the incredible complexity of these ecosystems that are still operating in natural balance, an opportunity that is becoming increasingly rare in our human-modified world. The information they collect, and the conclusions they draw from it, is helping to determine the best way to protect this unique ocean region for generations to come, and sheds some light on how we can restore our island ecosystems back home.

Ongoing research in the Hawaiian Islands National Wildlife Refuge (HINWR), Midway Atoll National Wildlife Refuge (MANWR), Kure Atoll State Wildlife Sanctuary (KASWS) (Mālama) and Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve (NWHICRER)

Ongoing monitoring of terrestrial plants and birds
Long-term monitoring continues of 4 endemic endangered landbird species, 20 seabird species, 5 shorebird species, and 106 plant species that occur in HINWR, KAWS, and MANWR. Monitoring intervals range from year-round measurements made at permanently staffed stations (French Frigate Shoals, Laysan, and Midway Atoll) to irregular visits at some of the remote sites (Gardner Pinnacles and Mokumanamana) and include measurements of population size, reproductive performance, and breeding chronology. Seabird data are submitted to the Pacific Seabird Monitoring Database and represent the largest and longest set of time series of tropical seabird population data in the world.

Laysan ecosystem restoration
Various experimental horticulture procedures are underway for Laysan's ecosystem restoration project. Studies of out planting protocol and propagation techniques are ongoing at the field site. Researchers and bioloigsts live in a remote island camp using eco-friendly solar-generated heat, power, water-filtration system, and compost toilets.

Green sea turtle monitoring by U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)
Long-term monitoring of the trends in the green sea turtle (Chelonia mydas) nesting colony is ongoing at French Frigate Shoals in collaboration with the National Marine Fisheries Service, Honolulu Laboratory. Population monitoring began in 1973.

National Marine Fisheries Service monk seal recovery efforts
Field camps are currently located at French Frigate Shoals, Laysan, Lisianski, Pearl

and Hermes Reef, Midway, and Kure. Monk seal research activities have been occurring in the NWHI for many years. Studies have included activities such as collection of samples for fatty acid analysis, documenting entanglements, mobbing, tagging weaned pups, intra-atoll movement of weaned pups, instrumentation of seals with portable camera units, marking seals for population studies, diet supplementation for pups, shark tagging to study movement behavior and removal of sharks along with extensive observations of shark behavior.

Restoration by U.S. Coast Guard (USCG)
The USCG has partially removed the contaminated (PCBs and lead) from the landfill located on Tern Island. The landfill was created during the period the USCG operated a LORAN station at Tern. Recent breaches in the seawall have allowed erosion of the landfill into the atoll's lagoon, contaminating sediment, fish, and other biota.

Spinner dolphin research
Midway Atoll provides a critical habitat for approximately 320 resident dolphins to rest and socialize during the daylight hours. A cooperative reasearch effert between the U.S. Fish and Wildlife Service and the Oceanic Society described the socio-ecology of Stenella longirostris, the lagoon's resident spinner dolphins.

Midway contaminant studies
An evaluation of the impact of lead and other contaminants on the immune response in Laysan albatross chicks began in 2000. Other research includes evaluation of contaminated nest soil and its contribution to chick/adult hormonal status (e.g., thyroid), and chick fledgling success in black-footed albatross.

Midway restoration
Before the Navy left Midway, it devoted millions of dollars and significant effort into undoing some of the human imprints on the islands. Working hand-in-hand with the Fish and Wildlife Service, the Navy and its contractors demolished more than 100 deteriorated buildings, removed scores of under- and aboveground fuel storage tanks, and cleaned up the environmental contaminants left by years of military operations. The Navy also removed a tug and barge thought to be the source of high levels of PCB fish contamination. Monk seals had used this barge as a haul out.

Bird aircraft interaction
A study to gather more information on the flight patterns used by seabirds crossing Midway's runway started in November 2001. It was based on the 2000 pilot-season project that monitored seabird flights in relation to wind speed and direction, time of day, landscape features, and species. The goal is to develop a means of communicating bird traffic levels to incoming and outgoing aircraft pilots.

Research Programs with the NWHI Coral Reef Ecosystem Reserve
The Reserve leads and supports scientific and cultural research in the NWHI that helps to provide long-term protection for the area's marine resources and cultural heritage. The Reserve's coral reef research program focuses on basic habitat characterization, mapping, and on ecosystem function. Reef surveys have recorded the diversity and abundance of fishes, algae, corals and other reef invertebrates throughout the archipelago, and ongoing monitoring programs keep track of their health. NOAA sponsored mapping expeditions have used multibeam sonar to map previously uncharted features on the ocean bottom, as well as collect more detailed and accurate data on shallow water features. Through radio tagging of large predatory fish such as sharks and jacks, and through genetic studies of fishes the Reserve is trying to discover how all these reef systems are connected, and

how best to manage them to preserve ecosystem function.

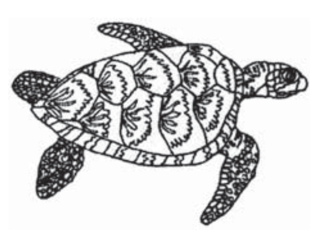
Historical and cultural resources such as shipwrecks have also been documented on shallow reefs by Reserve archaeologists, and the Reserve has supported several Native Hawaiian cultural expeditions to the islands. Research in deeper offshore waters has utilized multibeam sonar and submersibles to document rarely seen biological resources and topographical features within Reserve waters. The results from these research efforts are used to determine the best methods for managing the largest coral reef ecosystem in the United States, and to provide lasting protection for its resources.

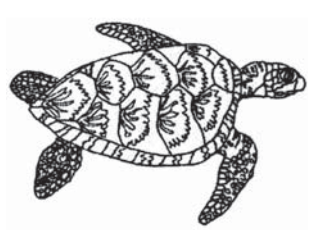
NOAA led Multi-Agency Marine Debris Cleanup Program
A NOAA led multi-agency marine debris cleanup program has been operating in the NWHI since 1997, and as of 2005 has removed nearly 500 tons of marine debris from the shallow waters and reefs. Each year, NOAA NMFS Coral Reef Ecosystem Division coordinates a several month long cleanup expedition to the islands that removes derelict fishing nets, and other large debris that pose a severe entanglement hazard to marine life such as monk seals, sea turtles, and large fish. The nets also act as giant bulldozers when they are pushed into shallow waters by waves and currents. Once in shallow water they crush corals, and destroy the reef structure. Each year it is estimated that 30 to 60 tons of new debris arrive in the NWHI, mostly in the form of derelict fishing nets from North Pacific fisheries. New programs to identify and collect nets at sea before they cause damage in shallow waters, and prevention programs to stop the debris from getting into the ocean in the first place are being implemented to address this huge problem.

Vessel Hull Inspection Program
The NWHI Coral Reef Ecosystem Reserve, along with other agency partners active in the NWHI, has instituted a hull inspection program for vessels entering the NWHI. This program attempts to prevent the introduction of non-native or invasive organisms into the NWHI from fouling on ship hulls, or from ballast water containing these organisms. As of 2005 the program was in its first full year of operation and had already identified and removed several organisms attached to ship hulls that may have been introduced into the NWHI. Introduction of alien and invasive species to the NWHI by human mechanisms is a primary management concern for all agencies attempting to protect this special place.

Source: United States Fish & Wildlife Service. (2002, March). Research in the NWHI National Wildlife Refuges and Kure Atoll Wildlife Sanctuary. Honolulu, HI: Author.

NWHI Coral Reef Ecosystem Reserve text from Andy Collins





NWHI Legal Status and Protection

The early protections afforded the region resulted from public outcry against exploitation of the area's rich natural resources, and the protections being discussed today are in response to world-wide losses of coral reefs, the need to protect species on the brink of extinction, and a rising awareness that our vast oceans are suffering from human impacts and are not "bottomless." A multitude of state and federal agencies manage and help protect the area known as the Northwestern Hawaiian Islands. From Nihoa Island to Kure Atoll, this area, excluding Midway Atoll, lies within the State of Hawai`i.

In 1857 Kamehameha IV visited Nihoa and annexed this island as well as the rest of the NWHI to the Hawaiian Kingdom. Most of the NWHI were incorporated into the United States of America as part of the Territory of Hawaii on July 7, 1898.

The earliest legally authorized federal protection occurred in 1903 when President Theodore Roosevelt put Midway under Navy Department control in Executive Order 199-A to protect Midway's seabirds from Japanese poachers and squatters. Later, in 1909, he set aside all the "other" islets, atolls, and reefs extending 1200 miles northwest of the main Hawaiian Islands from Nihoa to Kure to protect seabirds from slaughter for the millinery trade. This earlier known "Hawaiian Islands Bird Reservation" is now called Hawaiian Islands National Wildlife Refuge and is administered by the U.S. Fish and Wildlife Refuge. With the exception of Midway and Kure Atolls, this Refuge includes the islets, atolls, and reefs lying northwest of the main Hawaiian Islands.

Kure Atoll became the only state-managed land in the NWHI in 1978 when it was established as a State Seabird Sanctuary managed by the State of Hawai`i, Department of Land and Natural Resources.

In 1996, Midway Atoll became its own separate and unique National Wildlife Refuge, now managed by the U.S. Fish and Wildlife Service as Midway Atoll National Wildlife Refuge.

The State of Hawai`i claims jurisdiction over the waters within 3 nautical miles of land. Under an administrative agreement, the U.S. Fish and Wildlife Service co-manages with the State of Hawai`i Department of Land and Natural Resources more than 610,000 thousand acres of submerged shoals, coral reefs, and seamounts surrounding the atolls and islets. Fishing is currently prohibited within these co-administered Refuge boundaries. The Department of Land and Natural Resources Division of Aquatic Resources is in the process of establishing fishery management areas within State waters surrounding the NWHI. Fisheries regulations in Federal waters from 3 to 200 nautical miles are enforced by the U.S. Coast Guard and National Marine Fisheries Service (NMFS).

The Western Pacific Regional Fishery Management Council proposed regulations that were accepted by National Marine Fisheries Service establishing a Protected Species Zone for endangered Hawaiian monk seals that extends for 50 nautical miles around each Refuge island and includes a 100-nautical-mile wide corridor connecting the Refuge islands. Pelagic longline fishing is prohibited within this zone, but commercial bottomfishing, recreational, and subsistence fishing are allowed except where restricted by Reserve Preservation Areas established under Executive Order 13196.

In December 2000, the NWHI Coral Reef Ecosystem Reserve (Reserve) was created by Executive Order 13178, as modified by Executive Order 13196, to conserve and protect the coral reef ecosystem and related natural and cultural resources of the area.

At approximately 84 million acres, it is the largest conservation area in the U.S. and the second-largest in the world.

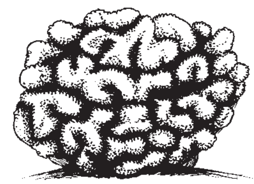
The Reserve is 1200 nautical miles long and 100 nautical miles wide and extends along the entire NWHI, excluding land areas, State of Hawai`i waters, and Midway Atoll NWR. The Reserve is managed under the Department of Commerce, National Oceanic and Atmospheric Administration National Marine Sanctuary Program. As directed by the executive orders that created it, the Reserve is going through a national marine sanctuary designation process and may become the nation's 14th National Marine Sanctuary. These initiatives provide the public with an unprecedented opportunity to participate in determining the health and future of this ocean wilderness. It is the hope of the Navigating Change initiative to inspire Hawai`i's people to take action.

Species in NWHI Listed as Endangered or Threatened

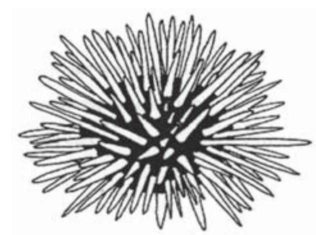
Special Status Species:	Status under the Endangered Species Act
Green sea turtle	Threatened
Hawksbill sea turtle	Endangered
Hawaiian monk seal	Endangered
Humpback whale	Endangered
Nihoa millerbird	Endangered
Nihoa finch	Endangered
Laysan finch	Endangered
Laysan duck	Endangered
Cenchrus agraminoides var. laysanensis (plant)	Endangered (may actually be extinct)
Mariscus pennatiformis ssp. bryanii (plant)	Endangered
Loulu, pritchardia remota (plant)	Endangered
Schiedea verticillata (plant)	Endangered
Amaranthus brownii (plant)	Endangered

Thirteen Things You Can Do to Help Protect Hawai`i's Coral Reefs

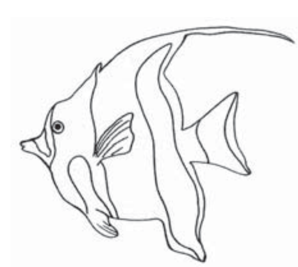
1. Support reef-friendly businesses
   - Ask what your dive shop, fishing store, and tour operators are doing to help prevent damage to Hawai`i's coral reefs.
   - Encourage businesses to sponsor and donate a share of their profits to reef management and education activities.
2. Please don't pollute
   - Let others know that plastics in the water can damage and kill fish, marine mammals, turtles, and seabirds.
   - Spread the word that the pollution released on our islands eventually winds its way into the ocean where it harms our reefs.



3. Learn more about our reefs
   - Volunteer at an environmental organization/agency and become a member of a local aquarium, zoo, or environmental center.
   - Help with reef and beach clean-ups.
   - Learn more so you can help others understand the fragility, value, and wonder of Hawai`i's coral reefs.
4. Report dumping, poaching, or other illegal activities
   - Since environmental enforcement officials cannot be everywhere, you can take down as much detailed information about the illegal activity as possible and contact the appropriate authorities. DO NOT directly confront possible violators.
5. Never anchor directly on the reef
   - Make use of the State's Day-use Mooring System where available.
   - Anchor in sand away from reefs whenever possible.

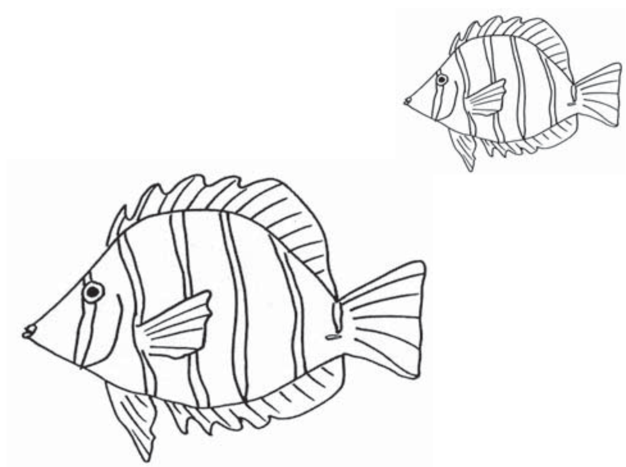


6. Take steps to decrease overfishing
   - Observe fishing regulations and only harvest what you need.
   - Tell others that we all need to kōkua (help) so there will be fish for your own children or grandchildren to catch in the future.
7. If you SCUBA dive or snorkel, don't touch
   - Take a moment to think about your actions in the water.
   - Remember that your fins, hands, and diving equipment can be lethal weapons that damage the delicate, tiny animals that build the reef.
8. Get involved in the legislative process
   - Contact your elected officials and encourage them to support legislation what will protect Hawai`i's reefs.
   - Let others know that we need to change the fact that Hawai`i has the fourth longest coastline in the U.S. but ranks 48th in overall funding for fish and wildlife protection, and last in overall state spending on environmental protection!
9. Be an informed consumer and responsible aquarium hobbyist
   - Consider carefully the impact of purchasing preserved coral or aquarium fish. By law, coral for aquaria have to come from outside the State of Hawai`i. Still, their removal causes negative impacts on the reefs of the country they're from.



- Never release exotic aquarium species into Hawaiian waters.
  Hawai`i is a very unique place containing marine organisms found nowhere else in the world. Introduction of non-native marine life can severely affect the ability of our native species to survive.

10. Be a wastewater crusader
    - Help prevent marine water pollution by cutting down on the amount of chemical pesticides and fertilizers you use.
    - Conserve fresh water.
11. Support the creation and maintenance of marine parks and preserves
    - Let others know that most of Hawai`i's marine resources are over-fished, and that by setting aside protected habitat we will enhance nearby areas, thereby allowing renewed fishing and gathering opportunities.
12. Promote responsible development
    - Spread the word that as we develop more and more of our undeveloped coastal—and inland—areas, we place greater pressure on the natural ecosystems to adapt. Most of our native island species depend on our precious few undeveloped natural habitats and have nowhere else to go.
13. Practice resource stewardship
    - Learn and follow the rules and regulations about fishing, gathering, and use of our marine resources.
    - Spread the word that many marine species are unique to Hawai`i, and that our reefs need our help.



NOTE: Many of these ideas were adopted from the NOAA Coral Reef Home Page (www.coralreef.noaa.gov) and the DLNR Partnership for Resource Protection brochure, the IYOR informational brochure, and the ICUN Coral Reefs of the World lists of Impacts on Reefs

Glossary of Terms

A

acre – land area equivalent to 43,560 sq. feet; there are 640 acres in one square mile

ahupua`a – traditional Hawaiian land division usually extending from mountain summits to the outer edge of the reef

`āina – land, earth; "that which feeds"

algae – simple plants that live in water

alternatives – one of two or more choices

apex predators – animals at the top of the food chain

archipelago – a chain or cluster of islands surrounded by open sea

atoll – a ring-shaped coral reef or string of coral islands, usually enclosing a shallow lagoon

B

basalt – hard and dark volcanic rock formed by the cooling of lava at or near the Earth's surface

baseline – information collected about an ecosystem at a known point in time that creates a "picture" for measuring change in the future

biodegradable – capable of being broken down by natural processes

biodiversity – the abundance of native species in an area

biomass – total weight of living things in a defined area

bolus – fat, cigar-shaped mass of materials that is regurgitated by some types of seabirds and contains materials that were indigestible (e.g. plastics, squid beaks)

C

capping – stage in the evolution of a typical Hawaiian volcano during which rocks build a steeply sloping cap on the main shield of the volcano. Eruptions are less frequent but more explosive than in other volcano types. The summit caldera may be buried.

carnivores – animals that feed on other animals

community – an assemblage of plants and animals living within a defined area

conclusions – general statements about findings

consumers – animals that get their energy by feeding on plants or other animals

D, E

decomposers – organisms that help to break down plant and animal matter into nutrients that producers need to grow; scavengers

ecosystem – the interacting system of living organisms and their environment

emergent – above the surface of the water endangered – plant or animal species in danger of going extinct

endemic – restricted to an area (e.g., a species found only in one area on Earth)

erosion – wearing away of the land by the action of water, wind, or ice

extinction – the total disappearance of a species

F, G

fertilizers – substances (natural or chemical) that supply nutrients to the soil

food chain – a sequence of organisms, each of which uses the next lower member of the sequence as a food source

foraging ground – place from which an animal gets its food

fringing reef – coral reef that grows in shallow water and slopes sharply toward the sea floor

guano – manure composed chiefly of the excrement of sea birds; valued as a fertilizer

guyot – a flat-topped submerged seamount

H

habitat – the place or environment in which a plant or animal naturally lives and grows

hazardous – potentially harmful

herbivores – animals that feed on plants

ho`okele – navigator

ho`okupu – tribute, tax, ceremonial gift-giving as a sign of honor and respect

human disturbance – in this context, human activities that result in harming plants or animals

hypothesis – educated guess

I, J, K

indigestible – digestible with difficulty or impossible to digest

interdependence – in this context, the mutual dependence of plants and animals

invertebrate – an animal without a backbone

kapu – taboo, prohibition; forbidden; sacred

kōkua – to help, assist

kuleana – right, privelege, concern, responsibility

kupuna – elder; grandparent, ancestor, relative or close friend of grandparent's generation

kupūna – plural of kupuna

L, M

L_{50} – the length (L) of a fish species at the time when approximately 50% are reproductively mature (only half will be able to spawn at that size)

latitude – imaginary circles around the Earth, parallel to the equator laulima – to work together

limpet – mollusk with a conical shell that clings to rocks and corals; `opihi

longitude – imaginary circles on the surface of the Earth passing through the North and South poles at right angles to the equator

low-level carnivore – animal, smaller than apex predators, that feeds on organisms lower in the food chain

mālama – to take care of

mālama `āina – to take care of the land (including the sea)

marine debris – human-made solid material that is dumped or washed into the marine environment

marine protected area – an area in which marine resources receive special protections

N

National Marine Sanctuary – a system of underwater parks managed by NOAA's Office of National Marine Sanctuaries intended to protect and preserve biological, cultural, and historical resources

National Wildlife Refuge – a federal designation given to a protected area managed by the U.S. Fish and Wildlife Service for the primary purpose of providing necessary habitat for wildlife

navigate – to steer a course

non-biodegradable – not capable of being broken down by the actions of microorganisms

NOWRAMP – Northwestern Hawaiian Islands Reef Assessment and Monitoring Program (the NOWRAMP expedition surveyed the NWHI marine ecosystems)

nutrients – any substance that promotes growth in living organisms

O, P

omnivores – animals that feed on both plants and other animals

pesticides – substances used to control pests

photosynthesis – the process of using energy from the sun to make starches and sugars from carbon dioxide and water

phytoplankton – single-celled or multi-celled plants

procedures – sequence of actions used in an experiment

producers – organisms that use energy from the sun to produce their own food

predator – an animal that hunts and kills other animals for its food

prey – an animal hunted or caught for food

purpose – goal

R - Z

reproductive maturity – age or size at which an organism is able to reproduce

reproductive size – the size of an organism when it is sexually mature results – what happened

secondary activity – (also referred to as "rejuvenation") renewed volcanic activity that sometimes occurs after the bulk of an island is formed and the volcano has experienced considerable erosion

shield-building – formation of a gently sloping volcano in the shape of a flattened dome and built almost exclusively of lava flows

shifting baseline – using information recorded at a different time as a baseline by which to measure change

submerged – beneath the surface of the water

sustainable use – use of a resource in a way that allows future generations to meet their needs

wayfinding – the art of navigating without instruments, using clues in the environment

zooxanthellae – microscopic, single-celled algae that live inside the tissues of corals and some other animals

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