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Project Kāhea Loko

"The Call of the Pond"

A Teacher's Guide to Hawaiian Fishponds
Grades 4 - 12

Produced by

The Pacific American Foundation

in cooperation with
Waikalua Loko Fishpond Preservation Society,
Hawai'i Department of Education
and University of Hawai'i Sea Grant College Program

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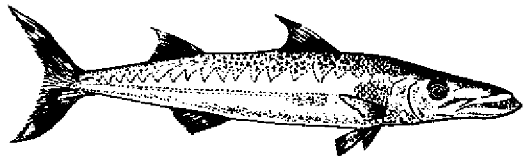

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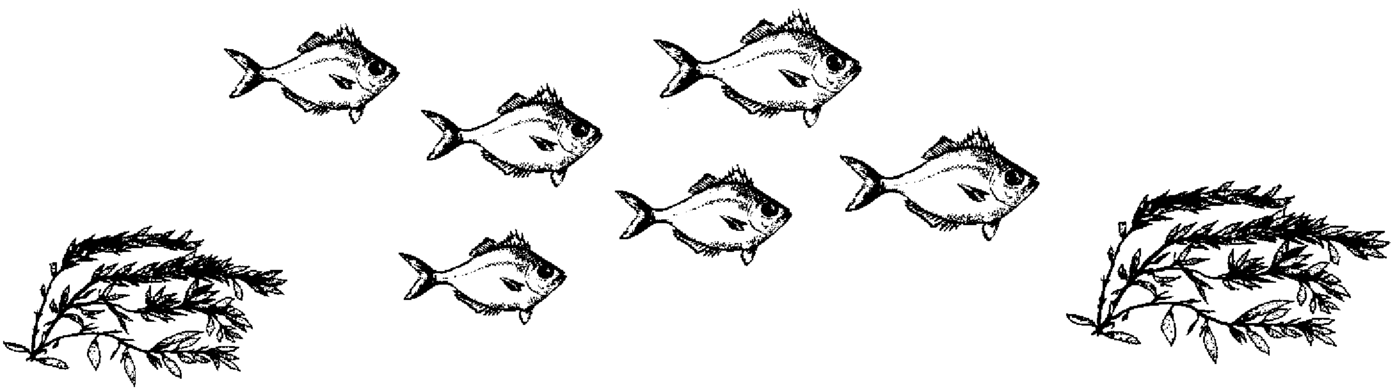

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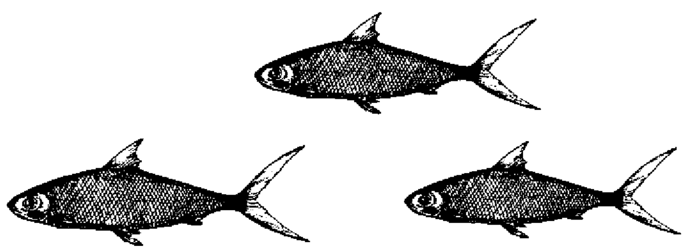

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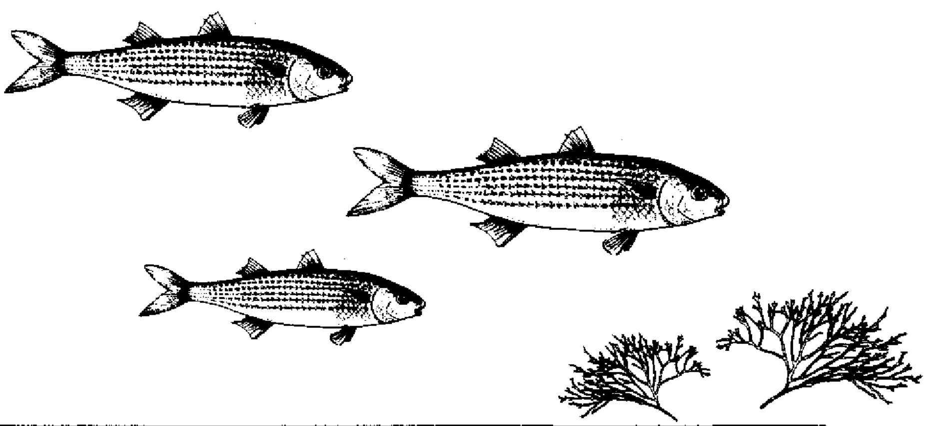

Participating Schools and Organizations

Kāne'ohe Elementary
Hale'iwa Elementary
Pū'ōhala Elementary
University of Hawai'i Lab School
Waimalu Elementary
'Āhuimanu Elementary
Waiau Elementary
Waimānalo Elementary
Salt Lake Elementary
Maunawili Elementary
Kilohana Elementary
Kualapu'u Elementary
Lokelani Intermediate
Castle High School
Ke Kula 'O S.M. Kamakau Immersion School
Waipahu High School
Campbell High School
'Īao Intermediate School
Konawaena Middle School
Ānuenue Immersion School
Kaua'i High School
Nā Pua No'eau, Hilo
Kaloko-Honokōhau National Historical Park, Kailua-Kona
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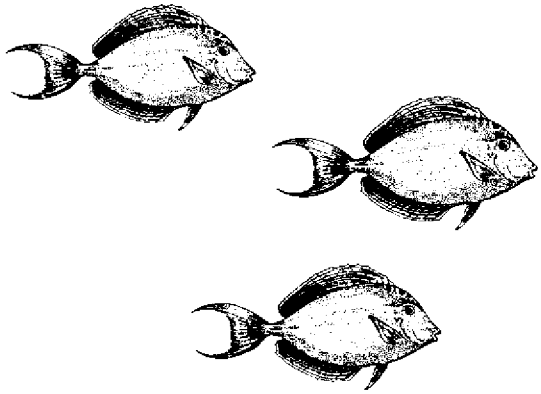

Principal Loko I'a Testing Site

Waikalua Loko, Kāne'ohe, O'ahu
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Waikalua Loko Fishpond Preservation Society
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Chuck Eakes
Dr. Clyde Tamaru
Dan Vierra
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Ikaika Hussey
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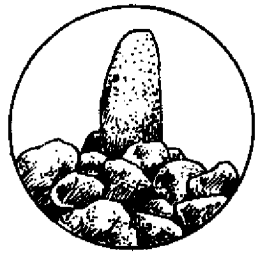
Frank Kawaikapuokalani Hewett

Project Kāhea Loko Introduction

"Let that which is unknown become known."
John Papa Ii (1959)



Let us not allow the broken walls of the loko iʻa (fishponds) to separate us
from that which was known and practiced in the past.
The foundations of the walls are still evident, as are the wisdom and knowledge of our kūpuna.
The reflections of the sun, moon, and stars upon our waters are as old as time.
Let these be beacons of light to guide our haumāna (students) to these ponds of knowledge.
Let us help them rebuild the walls of these living resources where they can gather,
as did the pua iʻa (fish fry), to grow and be nurtured.
With education and inspiration, the legacy of our ancestors
can be preserved and passed on to future generations,
a mau a mau, (forever and ever).
Christine Tamaru (2001)

Project Overview

Kāhea Loko is "the call of the pond." From the ocean currents surging through the stone-walled channels to the excited cries of haumāna (students) discovering fishpond life, the loko iʻa (fishpond) calls to us in many ways. From the broad perspective of the ahupuaʻa (major land division), the loko iʻa helps us to appreciate the connection between land and sea and to experience the rhythm of tides and seasons. From an intimate perspective, the pond leads us to discover how the tiniest life forms fit into the web of pond life.

The loko iʻa calls to us to honor the values, traditions, and achievements of Hawaiian kūpuna (ancestors) so that we may incorporate these into our own lives. These kūpuna had the highest regard for the loko iʻa believing in the interrelationship of all things: sky and earth; ocean and land; land and human; human and gods. "The Hawaiian and all other natural forms of his world were the beneficiaries of this primal cadence and flowed with the rhythm of the universe" (Kanahele, 1997). The Hawaiians' intimate knowledge of life cycles, seasonal rhythms, and tides and currents was the foundation for the remarkable engineering feats they achieved in the construction of loko iʻa.

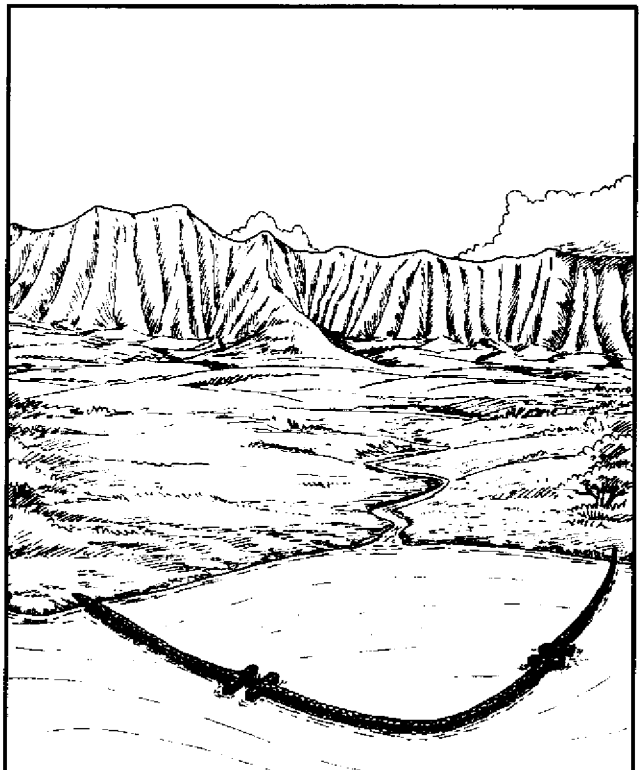
Hawaiian kūpuna revered the mauli (life force) of the fishpond. This humility and respect for all things, living and nonliving, helped them to be pono or in balance with nature. Values such as mahalo, aloha, and mālama had multiple meanings for these kūpuna, and these values were deeply imbedded into the culture, language, and lifestyle.

It is our kuleana (responsibility) as teachers to enlighten our students — using these values within contextual frameworks such as the loko iʻa so that our haumāna can connect with and nurture that life force inside themselves and in their environment. The overall goal of Project Kāhea Loko is mālama i ka ʻāina (to care for the land) — to help our students understand why it is so important to conserve cultural and natural resources and to discover how we can restore and care for our historic fishponds.

To achieve that goal, Project Kāhea Loko developed a complete set of field-tested curricula for Grades 4 - 12 designed to meet selected academic and performance standards set by the Hawai'i Department of Education (DOE). The project seeks to incorporate Hawaiian fishponds (loko i'a) as learning tools into the mainstream educational system for Hawai'i's school children. Working in concert with other fishpond projects, teachers, pond operators, historians, Hawaiian language and cultural experts, the Kāhea Loko team has collected and organized fishpond-related cultural, historic, and scientific data into culturally appropriate curriculum units for use in Hawai'i's schools. Project Kāhea Loko is a three-year project funded by the U.S. Department of Education and administered by the Pacific American Foundation.

Organization of Teacher's Guide

Each unit begins with an introduction that includes background information on the content covered for Grades 4 - 12. A conceptual framework for each grade level cluster, 4 - 5, 6 - 8, and 9 - 12, separates the activities within each unit. These frameworks include the social studies and science standard benchmarks that form the basis of the materials, the focus questions for each instructional activity, key concepts and a summary of activities to assess student achievement. The frameworks are followed by culminating activities that challenge students to apply what they have learned in the units. Sample rubrics to assess student achievement are also provided. These rubrics will be most effective if students are involved in the decision-making on the criteria that will ultimately be used to assess their work, and if students view the criteria as a challenge to strive for their best work. See the Appendices for more information on creating rubrics with students and using portfolios for assessment of students' work.



Unit 1 The Physical Setting

Hawai'i DOE Social Studies Standards

- World in Spatial Terms
- Places and Regions
- History: Change, Continuity, Causality

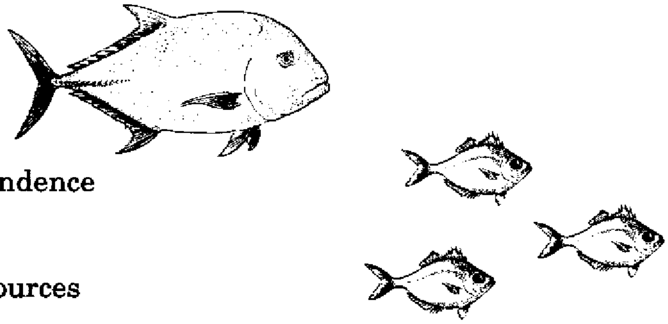
Hawai'i DOE Science Standard

- Using Unifying Concepts and Themes

Unit Overview

The instructional activities in Unit 1 help students to discover different types of fishponds and fishtraps and to understand how these structures were built to take advantage of different physical features within an ahupua'a. A Pacific island perspective is introduced in Grades 6 – 8 as students delve into questions about the extensive development of fishponds in Hawai'i compared to other island areas.

Unit 2 Life in a Fishpond



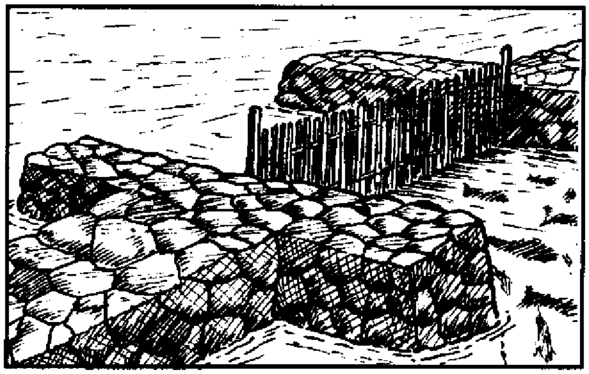
Hawai'i DOE Science Standards

- Cycle of Matter and Energy Flow
- Organisms and Development: Interdependence
- Scientific Inquiry
- Earth in the Solar System
- Mālama I Ka 'Āina: Conservation of Resources

Unit Overview

Unit 2 introduces students to the diversity of plants and animals that live in a fishpond. Activities help students investigate interdependence among species, how lōkahi (balance) is maintained in the pond, and how marine organisms respond to seasonal and tidal changes.

Unit 3 Early Hawaiian Fishponds



Hawai'i DOE Social Studies Standards

- Cultural Systems
- Historical Empathy
- Historical Inquiry
- History: Change, Continuity, Causality

Hawai'i DOE Science Standard

- Mālama I Ka 'Āina: Sustainability

Unit Overview

The activities in Unit 3 help students to explore how fishing evolved in Hawai'i from catching to growing fish, the ingenuity involved in fishpond engineering, and what traditional practices and mo'olelo (legends) can teach us about values that are important in Hawaiian culture.

Unit 4 Fishponds Today

Hawai'i DOE Science Standards

- Habits of Mind
- Mālama I Ka 'Āina: Sustainability
- Scientific Inquiry

Hawai'i DOE Social Studies Standard

- Citizenship/Participation

Unit Overview

Unit 4 challenges students to assess how fishponds and their uses have changed in Hawai'i, and to debate issues related to fishpond restoration today. The unit includes field studies at a fishpond and culminating activities that build on content addressed in the first three units.

Appendices

The Appendices include a Glossary that defines all of the vocabulary listed for each activity, a set of pond life cards featuring the plants and animals that live in fishponds, a list of suggested field trip sites and resource people to assist with field trips, and a list of suggested resources for further study of fishponds and fishtraps. There is also a section on rubrics and portfolios for assessing students' work.

Field Trip Notes

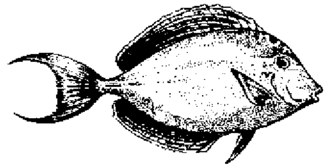
The concepts presented in this guide will come alive for students when they visit a fishpond and apply what they have been investigating in the classroom. Suggestions for organizing the field trip are included in Unit 4. Unit 1 in Grades 9 - 12 also includes a field study. If high school classes are unable to participate in two field trips, field activities from Units 1 and 4 could be combined. Data sheets for a fishpond exploration are included in these units. The pond life cards in the Appendices are also a useful resource for field studies.

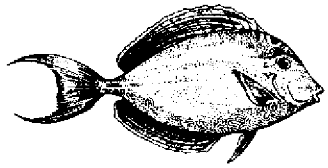
Website and Video Resources

For more information about Project Kāhea Loko, visit the Pacific American Foundation Website at www.thepaf.org. The Website provides students and teachers with photographs and information about fishponds around the state. Ultimately, the goal is to provide a link to facilitate the sharing of culminating projects with other schools. In this way, students throughout the state will contribute to a growing body of knowledge about fishponds in Hawai'i.

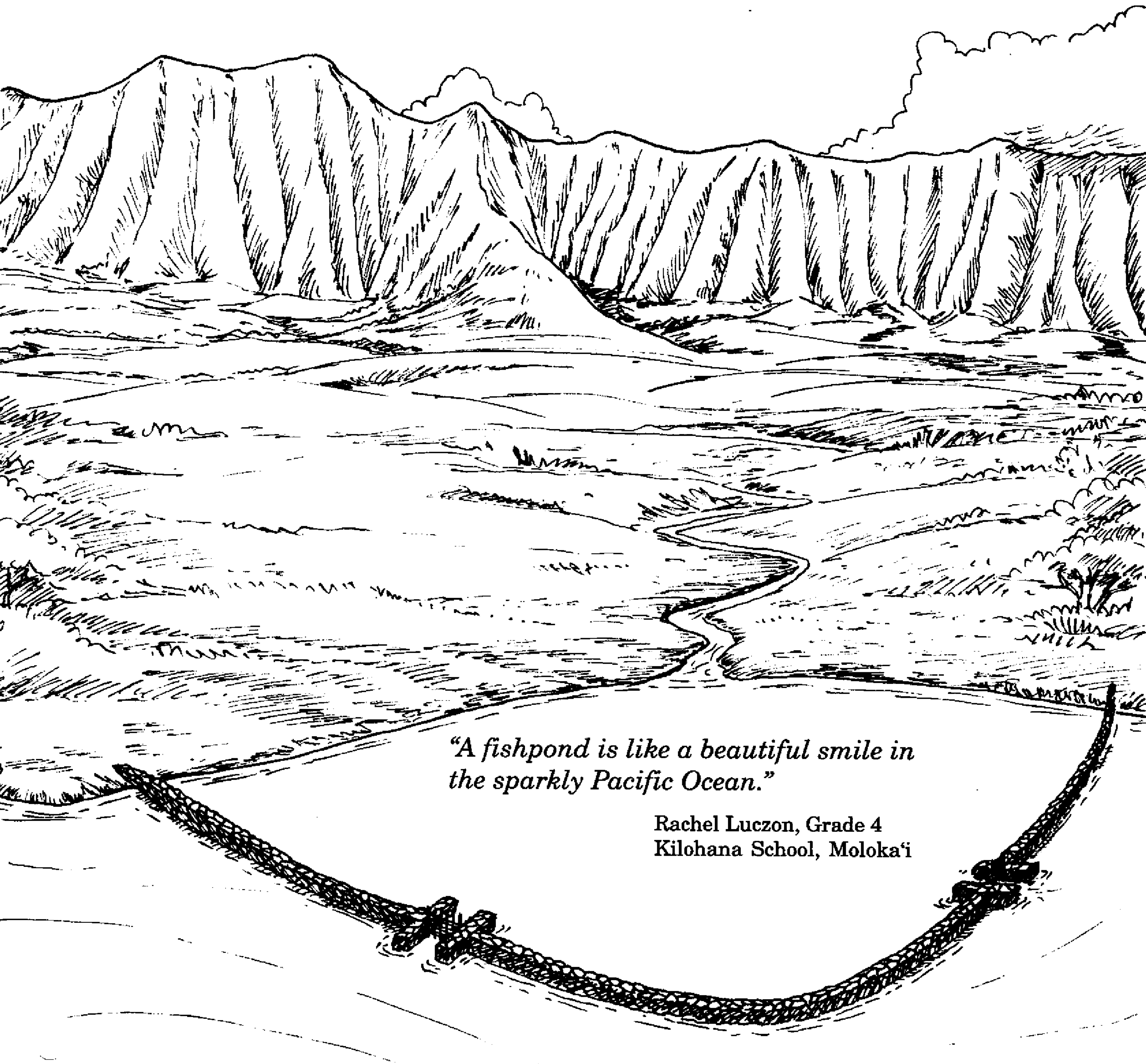
Project Kāhea Loko has produced a video, "Kāhea Loko: The Call of the Pond" to introduce students to loko i'a in Hawai'i. The video features students learning from Hawaiian kūpuna and fishpond managers about different types of ponds, how the loko i'a function, and what is being done to mālama (care for) fishponds today. Copies of the video can be obtained from the Pacific American Foundation (www.thepaf.org) or from the Hawai'i Department of Education Teleschool Office (808) 837-8004.

Kāhea loko—the call of the pond—beckons to you and your haumāna (students) to join us in a discovery of loko i'a.



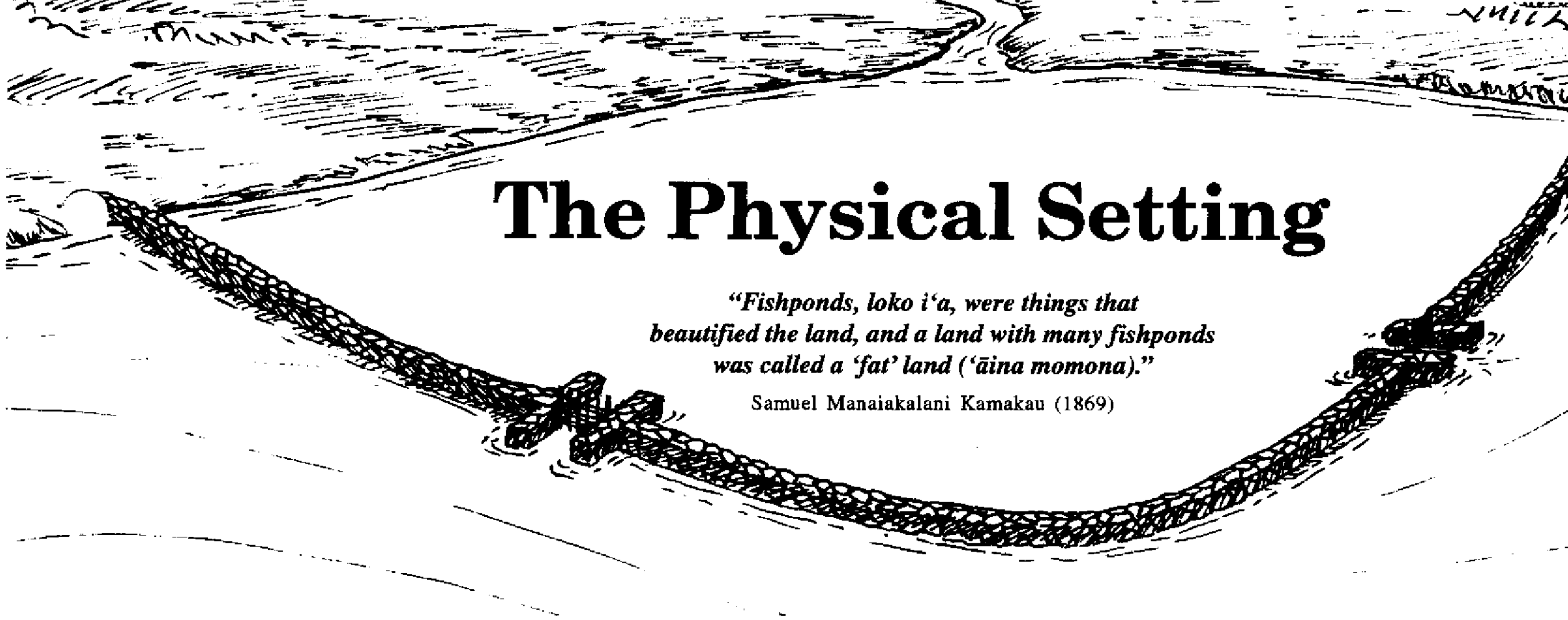


UNIT 1
The Physical Setting



"A fishpond is like a beautiful smile in the sparkly Pacific Ocean."

Rachel Luczon, Grade 4
Kilohana School, Moloka'i



The Physical Setting

"Fishponds, loko iʻa, were things that beautified the land, and a land with many fishponds was called a 'fat' land (ʻāina momona)."

Samuel Manaiakalani Kamakau (1869)

Fishponds are either human-made or natural enclosures of sea water (kai), fresh water (wai), or brackish water (wai kai) used for the raising and harvesting of various edible fish and plants. Fish farming has long been practiced throughout the world by many cultures. In Egypt, 4,500-year-old drawings in the tombs of the pharaohs show tilapia and mullet as food sources. The Chinese have raised common carp in dirt fishponds as early as 4,000 years ago, and they continue to do so today. Fishponds are known to have existed in ancient Mesopotamia and Assyria, and the nobility of Rome built both freshwater and saltwater ponds for raising fish. They were particularly fond of eels, as food and as pets.

While rock-wall fishtraps, similar to the loko ʻume iki in Hawaiʻi, are found in parts of Southeast Asia and throughout the Pacific, the fishpond totally unique to Hawaiʻi is the loko kuapā. The Polynesian settlers of Hawaiʻi developed a variety of fishponds and fishtraps to increase the availability of aquatic plants and animals for food as part of their ahupuaʻa aquaculture and agriculture system. The loko ʻume iki were most notably built along the southern coast of the island of Molokaʻi.

The development of loko iʻa (fishponds) for the specific purpose of sheltering and nurturing fish for consumption began as early as the 13th century in Hawaiʻi. The impressive fishpond walls we see today were built by thousands of workers passing stones from hand to hand.

The Hawaiian fishpond of the loko kuapā style is made of a massive stone wall extending on to the reef flat. In these walls Hawaiians built ʻauwai kai (channels) that allowed the exchange of water with each changing of the tide. The ʻauwai kai caused a swift current that attracted fish depending on which way the tide was flowing. A defining characteristic of the Hawaiian fishponds was the placement of a wooden mākāhā (sluice grate) in the ʻauwai kai (or ʻauwai in freshwater fishponds). This grate controls what goes in and out of the pond and allows for the easy collection of fish with the changing tide. The construction of fishponds using mākāhā represented a major milestone in the evolution of the Hawaiian people as it marked the transition from a hunter/gatherer existence to that of a farmer. In this case, however, it was the fish being farmed using the water as the pasture. The location of the pond was not by chance, as characteristically a fresh water source (such as a stream or spring) fed into the fishpond. The fresh water percolating through the ground or flowing from streams brings with it minerals and trace nutrients that enter into the pond and act as fertilizer for phytoplankton and algae, on which herbivorous fish like ʻamaʻama (striped mullet) and awa (milkfish) feed.

Without any external input, the loko kuapā ecosystem could support approximately 500 pounds of fish per acre. The true genius of the design, however, is seen in the way fish were stocked into the fishpond. The pua (fry) stages of certain kinds of fish and invertebrates migrate to the brackish water environment inside of the fishpond, undoubtedly attracted by the large amount of food and the safe haven of the nursery habitat. While still small, the fry can easily squeeze between the individual bars of the mākāhā and once inside of the fishpond they feed and grow rapidly. Soon, the fish are so large that they can no longer exit through the mākāhā and they become part of the fishpond community.

The Ahupuaʻa

Ahupuaʻa are traditional units of land in Hawaiʻi that vary in shape and size. They are political and ecological land units designed to meet a community's need for food and materials. Ahupuaʻa generally range from summit peaks or ridge crests, extending down slope, becoming wider as the land slopes downward and to the outer edge of the reef. The boundaries between adjacent ahupuaʻa usually conform to valley walls or ridges. The general concept of the ahupuaʻa is that the human community living within its boundaries would be self-sufficient in obtaining the resources needed for survival such as fish, water and land to grow kalo (taro), medicinal herbs, and trees for canoes and shelter. However, due to the wide range of elevation, rainfall and topography in the Islands, there are a number of ahupuaʻa that don't conform to this generalized ideal. For example, on Oʻahu, the ahupuaʻa of Waiʻanae reaches beyond Waiʻanae valley to include a wedge of land that extends to the summit of the Koʻolau range. In early times, this extended boundary enabled people living in the arid leeward area of Waiʻanae valley to gather resources from the wetter Koʻolau area.

People also shared resources among ahupuaʻa to obtain plants that only grow in certain areas. Pili grass, which was prized for thatching, grows best in dry leeward areas. Hala trees, which provide materials for weaving, grow best in wet windward valleys. Koa trees large enough for canoes were found in koa forests that typically grow at elevations above 3,000 feet on the larger islands.

Types of Fishponds and Fishtraps

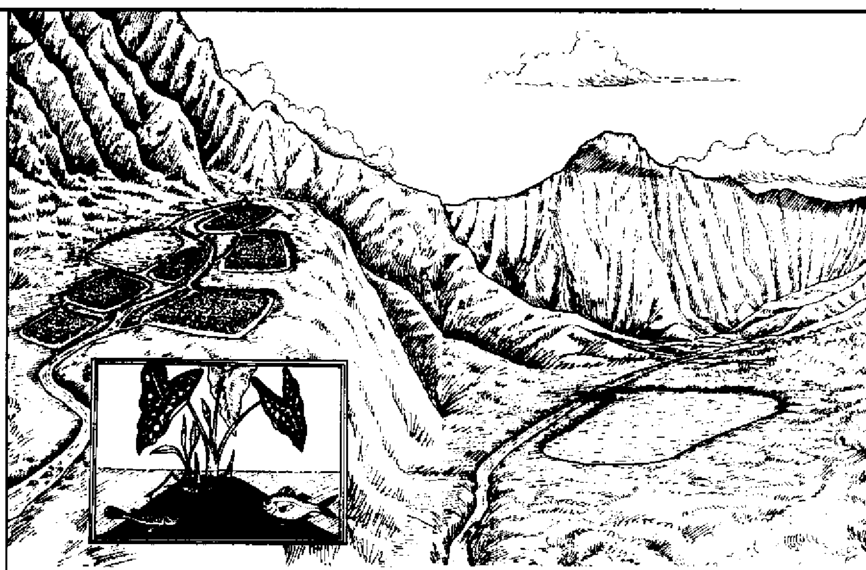
Inland Freshwater Fishponds
1 loko iʻa kalo or loko loʻi kalo
2 loko wai

Brackish Water Shore Fishpond
3 loko puʻuone or hakuone

Brackish/ Saltwater Large Walled Fishtrap with Lanes
4 loko ʻume iki

Brackish/ Saltwater Fishpond on Reef Flats
5 loko kuapā

Small Saltwater Fishtrap or Fish Shelter
6 umu 7 pā



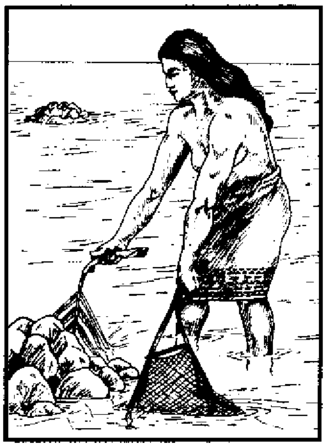
loko iʻa kalo or loko loʻi kalo *loko wai*

Politically, the ahupua'a were governed by a konohiki (land manager) who oversaw the right to use the resources within the ahupua'a and served as an intermediary between the chief and the haku'ohana, or representative of the resident families or commoners (maka'āinana). Konohiki were responsible to chiefs of greater rank (ali'i nui or ali'i) that ruled over a moku (an island or district). Within the ahupua'a, individual families were allowed to cultivate and inhabit smaller sections of land or 'ili. The konohiki also directed the people in the building and repair of fishponds whenever the ali'i nui commanded.

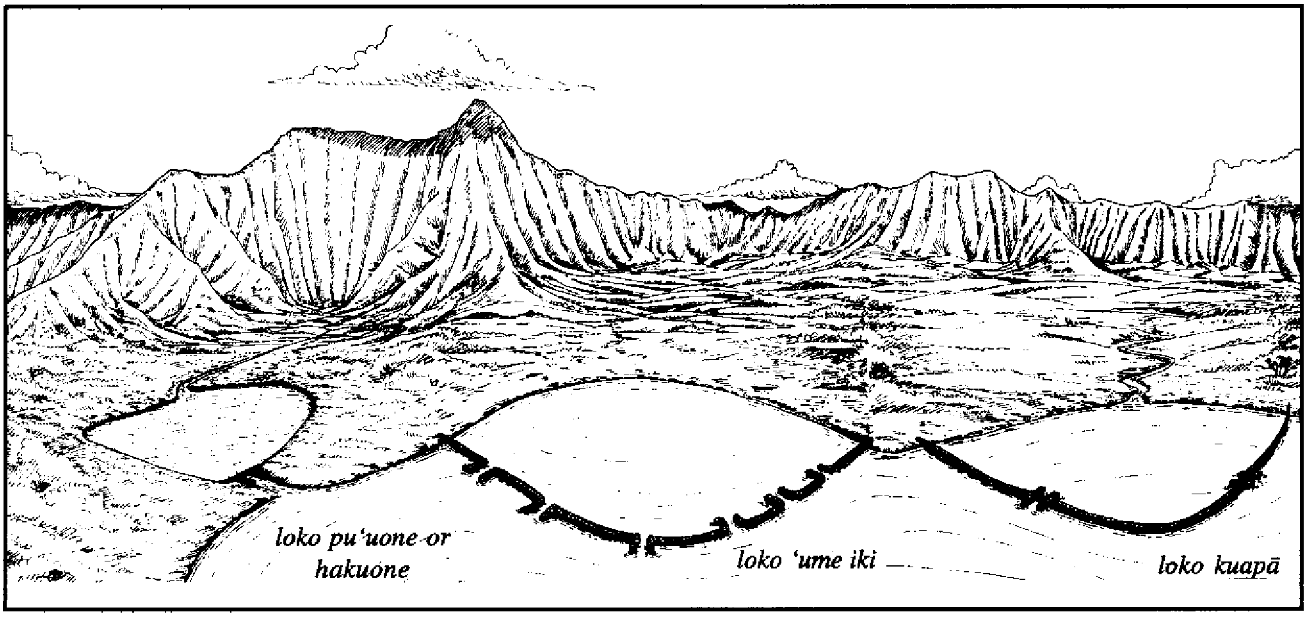
During the Makahiki (great annual harvest festival), an entourage of ali'i (chiefs) sometimes numbering 100 people or more, would tour the island, traveling from one ahupua'a to another. At the boundary of each ahupua'a, the residents placed an offering of some of their food crops, fish harvest, and feathers from forest birds for the touring ali'i. The offerings were placed at an ahu (collection of stones) that was adorned with the head of a pig (pua'a). The people in each ahupua'a would provide shelter and food for the ali'i and all those who traveled with them.

Types of Fishponds and Fishtraps

The types of fishponds or fishtraps built by the Hawaiians in a specific location were directly related to the physical attributes of a particular ahupua'a. "No two fishponds or fishtraps are identical in construction, shape, or internal components" (Kikuchi, 1973). The sizes of the ponds are random, as the early Hawaiians utilized nearly all of the naturally occurring bodies of water available. The size was determined by the topography. Perhaps the simplest in construction and the most diversified were the various fishtraps. Many of those used in Hawai'i are similar to those found throughout Polynesia.

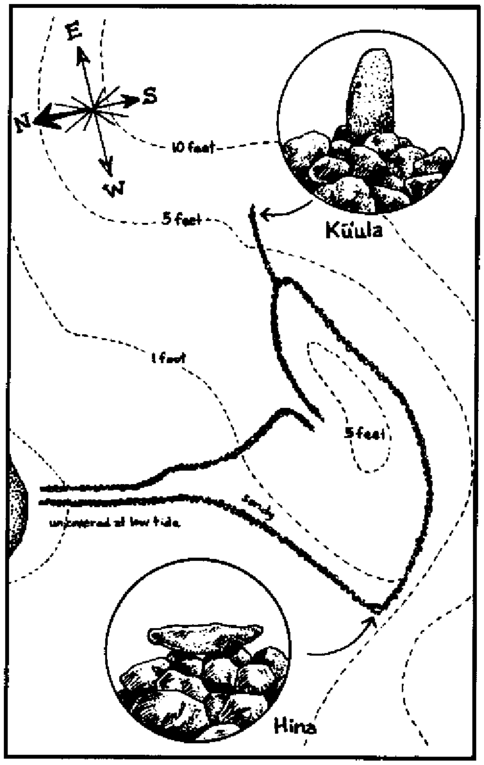


umu (small fishtrap)



Pā (a wall, fence, or enclosure) is a primitive type fishtrap that has a single lane to guide fish at low or high tide, but not at both. The purpose of all lanes was to guide the fish into an enclosure where they could be caught with nets.

While the topography of a few ahupua'a allowed for the construction of all types of ponds or traps, most land divisions could utilize only two or three types. For example, the largest number of loko kuapā (70) were built along the shores of O'ahu. The island of Hawai'i had few loko kuapā but the largest number of loko pu'uone. Along the island of Moloka'i, 13 loko 'ume iki were known to have existed (Farber, 1997). Some ahupua'a weren't suited to any ponds or traps.



pā (Hawaiian fishtrap)

The importance of fishponds in Hawai'i prior to European contact is illustrated by their numbers and distribution. In 1778, when Captain Cook arrived, about 360 fishponds were identified. In 1990, DHM Planners, Inc., conducted a thorough survey of fishponds and fishtraps in the six major islands and concluded the number to be 488, some distinguished only by remnants of the pani wai (walls) or mākāhā (sluice grates). The large number of ponds and traps on O'ahu (178) and Hawai'i (138) reflects the large human populations and the suitability of the landscape with its streams, estuaries, broad plains, and flat coastal reefs for the construction of fishponds. On O'ahu, 23 ponds were located around the shores of Kāne'ohe Bay. Some of the remaining ponds around Kāne'ohe Bay are Waikalua, He'eia, Kahalu'u, Nu'upia and Mōli'i. Until 1999, when the caretaker retired, Mōli'i pond was the oldest continuously operated pond in the state. The numbers of fishponds and fishtraps on the other islands were as follows: Moloka'i (74), Kaua'i (50), Maui (44), and Lāna'i (4) with the one pond on Ni'ihau not included. The sizes of loko kuapā ranged from one to 523 acres and loko pu'uone from several acres to 300 acres. The largest and most noticeable of the shoreline ponds, the loko kuapā, are the type that most people regard as Hawaiian fishponds (Farber, 1997).

The activities in this unit help students to explore different types of fishponds and fishtraps and to understand how these structures were built to take advantage of different physical features within an ahupua'a. The introductory Grades 4 - 5 lesson in this unit focuses on the first six types of fishponds and fishtraps indentified in the illustrations on the previous pages. The pā is introduced in the Grades 6 - 8 *Pacific Patterns* activity.

References

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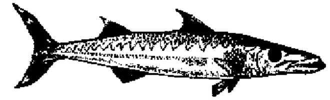


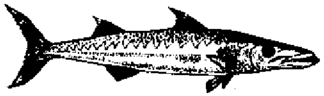
Unit 1 at a Glance

Grades 4 - 5

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: World in Spatial Terms Students use geographic representations to organize, analyze and present information on people, places, and environments.	**1A** . Why did Hawaiians build fishponds and fishtraps? What are the similarities and differences between the ponds and traps? **Activity:** ***Loko I'a***	• Hawaiians built different types of fishponds and fishtraps—enclosures of sea water (kai), fresh water (wai), or brackish water (wai kai)—to raise and harvest various edible fish and plants. • Fishponds and fishtraps have different key features in common, yet each type has unique features that take advantage of physical conditions in the environment.	Students produce booklets that include: • organized information about each type of fishpond or fishtrap with key features identified; • a completed chart comparing the ponds and traps (student activity sheet); and • a summary describing relationships — similarities and differences between different types of fishponds and fishtraps.
Social Studies: World in Spatial Terms Students use geographic representations to organize, analyze and present information on people, places, and environments.	**1B.** How did physical features within an ahupua'a determine where Hawaiians built different types of fishponds and fishtraps? **Activity:** ***Mauka to Makai: the Ahupua'a***	• Ahupua'a (traditional Hawaiian units of land) vary in shape and size and the distribution of geographic features. • Hawaiians built different types of fishponds to take advantage of existing geographic features within an ahupua'a. These features include the flow of water, natural depressions in the land, reefs, bays and sand bars.	Groups of students: • Create a section of an ahupua'a mural that depicts one type of fishpond or fishtrap, and labels of the physical features that are important for that type of pond or trap. • Present their section of the mural to other students in the school.

Culminating Activity

Students use data collected in this unit to complete a geographic representation of the ahupua'a where they live or where their school is located. Their maps include the major physical resources of the ahupua'a and drawings of actual and/or hypothetical fishponds. If there are no fishponds, students should sketch them in to their maps in locations where there are physical features to support them. Students complete written summaries of their ahupua'a that describe the major physical features and how these features support (or could support) different types of fishponds. ***(See rubric on next page.)***



Sample Rubric for Unit 1 Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Social Studies: World in Spatial Terms Show organization of collected data. ***Points*** _____	Information is in logical sequence and organized to communicate how physical features in the ahupuaʻa support different types of fishponds; makes comparisons to similar features in other ahupuaʻa.	Information is logically organized to communicate how physical features in the ahupuaʻa support different types of fishponds.	Information is not well organized and does not clearly communicate how physical features in the ahupuaʻa support different types of fishponds.	Not enough information and sequence of information is difficult to follow.
Explain the meanings, patterns and relationships found in geographic data. ***Points*** _____	Writing accurately describes the relationships between the types of fishponds and the different physical features within the ahupuaʻa and compares these relationships to those in another ahupuaʻa.	Writing accurately describes the relationships between the types of fishponds and the different physical features within the ahupuaʻa.	Writing makes few connections; content is good; but needs more detail about the relationships between types of fishponds and physical features of the ahupuaʻa.	Writing does not make connections between the types of fishponds and the physical features in the ahupuaʻa.
Construct a map that includes collected geographic data. ***Points*** _____	Map includes a legend or key and has features accurately located and labeled; shows evidence of extra effort to provide details that make the map easier to understand.	Map includes a legend or key and has key features accurately located and labeled.	Map includes some of the key features accurately located; map is adequate, but needs more information (such as a legend or key or labels).	Map does not include a legend or key; features of the ahupuaʻa are not accurately located; map is difficult to understand.

I NOTICED:

Loko I'a

- Why did Hawaiians build different types of fishponds (loko i'a) and fishtraps?
- What are the similarities and differences between different types of fishponds and fishtraps?

Hawai'i DOE Content Standard

Social Studies: Geography: World in Spatial Terms

- Students collect, organize and analyze data to interpret and construct geographic representations.

Grades 4 - 5 Performance Indicators

- Show organization of collected data.
- Construct a chart that includes collected geographic data.
- Explain the meanings, patterns and relationships found in geographic data.

Key Concepts

- Hawaiians built different types of fishponds and fishtraps — enclosures of sea water (kai), fresh water (wai), or brackish water (wai kai) — to raise and harvest various edible fish and plants.
- Fishponds and fishtraps have key features in common, yet each type has unique features that take advantage of physical conditions in the environment.

Activity at a Glance

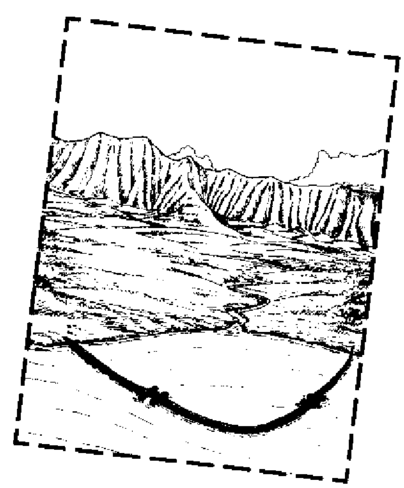
After viewing the Project Kāhea Loko video, students play a game to reinforce new vocabulary and discover different types of Hawaiian fishponds and fishtraps. These discoveries become the geographic data needed for the second part of the unit.

Time

3 class periods

Skills

reasoning, analysis, comparison, deduction



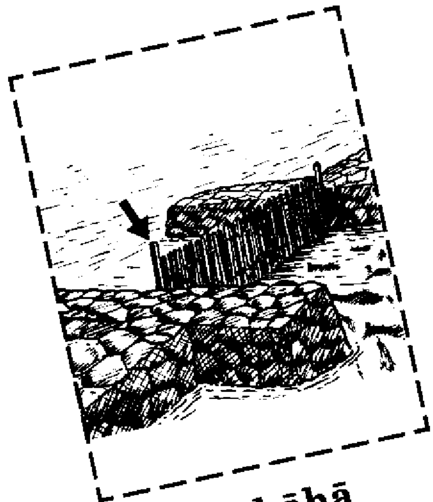
Assessment

Students produce booklets that include:

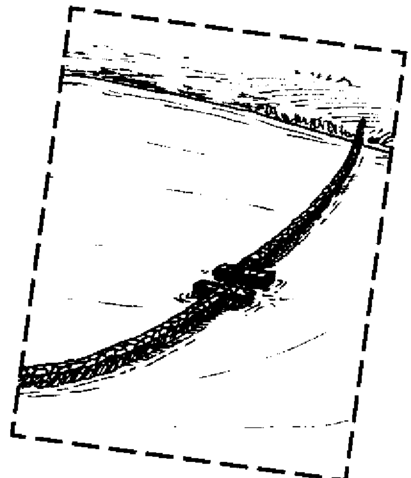
- organized information about each type of fishpond or fishtrap with key features identified;
- a completed chart comparing the ponds and traps (student activity sheet); and
- a summary describing relationships — similarities and differences between different types of fishponds and fishtraps.

Vocabulary

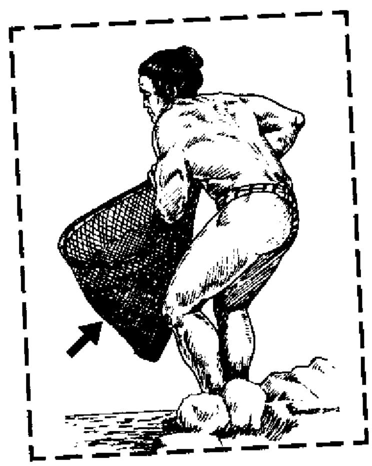
ʻauwai – ditch or canal
loko iʻa – fishpond
kuapā – seawall
mākāhā – sluice grate or gate
ʻauwai kai – ditch or small canal connecting the fishpond to the ocean
aliʻi – chief
makaʻāinana – commoner
puʻuone – sand heap or sand dune
loʻi – taro patch
algae or limu – aquatic plants and organisms containing chlorophyll
ʻupena – fishing net
mahiʻai – farmer
lawaiʻa – fisher



mākāhā



kuapā



ʻupena

Materials

Provided:

- Kāhea Loko video
- vocabulary cards
- fishpond descriptions
- fishpond illustrations
- student activity sheet

Needed:

- tape
- optional: additional pictures of fishponds (see the Kāhea Loko Website: www.thepaf.org)

Advance Preparation

Set up a chart with three columns, each labeled with a letter "K," "W" or "L." The "K" represents what students *know* about fishponds, the "W" will be *what* they'd like to learn, and the "L" will be what they *learn* as a result of this unit. Make a copy of the student activity sheet for each student. Copy one set of the vocabulary word cards and cut them apart. Make five copies of each fishpond description sheet. Make one copy of each fishpond and fishtrap illustration and cut along dotted lines. (Be sure to keep the drawing number on the cut sheet.)

Teaching Suggestions

1. Explain the K-W-L chart to students. Ask the students a series of questions to explore what they know about fishponds and record their responses under the "K."

    - What is a fishpond? (Agree on a general definition.)
    - Have you ever visited a fishpond? Describe it and where it was located.
    - How did Hawaiians decide where and how to build fishponds?

2. Introduce the Kāhea Loko video to the class by challenging students to watch it with the following questions in mind: Why did Hawaiians build different types of fishponds? What is the feature that the fishponds have in common and why is it important?

3. Explain that after watching the program, the class will be playing a game based on what students have learned.

4. Watch the video, and if desired, pause the videotape on the graphic screens to discuss the questions posed.

5. After watching the program, discuss why Hawaiians built different types of fishponds (*to cultivate and store fish for the ali'i, and to have fish available in mauka areas during times of need*) and what the important feature in the fishponds was (*the mākāhā, which trapped the fish and allowed water to circulate in the ponds.*) Record what students have learned under the "L" on the K-W-L chart. Then ask the students to generate a list of what they would like to learn and record their questions under the "W" on the chart.

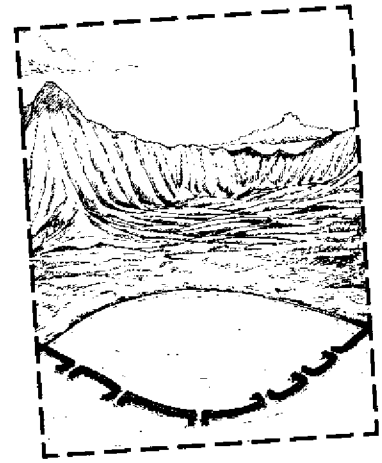
6. To build students' vocabulary for their fishpond study, divide the class into five small groups to play round one of the Loko I'a game. Display all of the vocabulary pictures by taping them up on the board. (Leave room for a word label to be taped below each picture.) Place the vocabulary words in a stack and explain that each word matches one of the pictures.

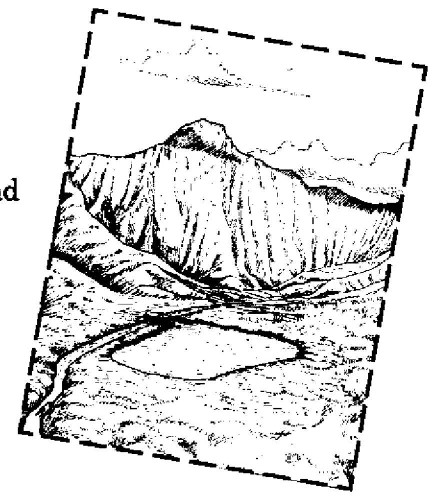
Loko I'a Game - Round 1

- Have teams take turns drawing a vocabulary word.
- Give a team 30 seconds to make a match and tape the word below the correct picture. Correct matches earn a team one point.
- If a team is not correct, the first team to signal may attempt to make a match and earn a point. If that team does not succeed, another team may try.

Bonus Round

- Once all words are drawn and matched, hold up a word and challenge teams to write a definition for the word. After 30 seconds, check their definitions and award two points for each correct answer.





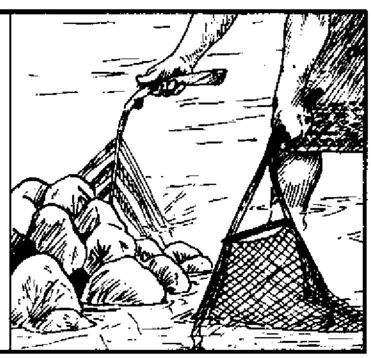
7. Remove the vocabulary cards and replace them with the fishpond and fishtrap illustrations. Explain that these are the "mystery" ponds for students to identify using the clues on the pond description sheets. These descriptions use the vocabulary words introduced in round one to describe each pond's key features.

   Loko I'a Game - Round 2

   - Distribute the first fishpond description to each team and read it aloud. Challenge teams to match the description to one of the numbered mystery ponds. Instead of calling out their answers, have students write the number of the pond and circle the clues in the description—the key features that describe the pond or fishtrap.
   - Ask teams to share their ideas and verify the correct match. See answers below.
   - Award each team two points for identifying the correct illustration and one point for each correct clue or key feature identified.
   - Distribute another fishpond description and read it aloud with students. Challenge the teams to again match the description to one of the displayed illustrations and circle the clues. Continue this process until teams have attempted to match all fishpond and fishtrap descriptions with the displayed illustrations.

Answers

1 Loko Kuapā
2 Umu
3 Loko Pu'uone
4 Loko Wai
5 Loko I'a Kalo
6 Loko 'Ume Iki



8. To summarize the game, ask students to help you arrange the six fishpond/fishtrap illustrations from mauka to makai. (The drawings fit together to form one continuous ahupua'a if you place them in the following order: 5, 4, 3, 6, 1, and 2; refer to the illustration on pages 2 and 3 of the Unit Introduction.) Discuss what students have discovered and fill in their K-W-L chart.

Discussion Questions

- What features do all Hawaiian fishponds have in common? *(mākāhā, ʻauwai or ʻauwai kai, fed by streams or springs)*
- Which fishponds and fishtraps were located near the sea? *(loko kuapā, loko puʻuone, loko ʻume iki, umu, and sometimes loko wai)*
- Which were located in the uplands? *(loko wai, loko iʻa kalo)*
- What would you like to find out about the different types of ponds?

9. Distribute the student activity sheet and ask students to complete the assessment activities. Answers to the student activity sheet are listed below.

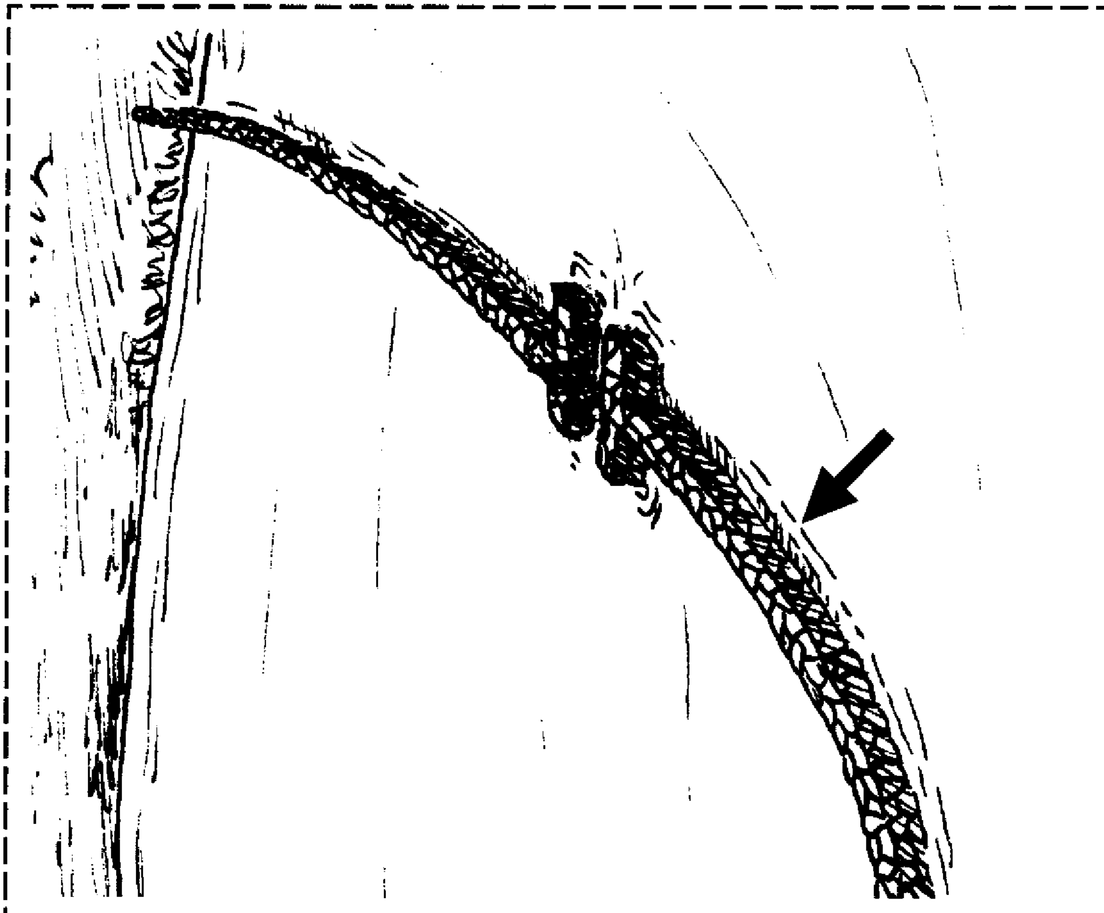
Type of fishpond or fishtrap	Uses mākāhā	Used only to trap fish	Fed by streams or springs	Used for growing kalo	Has no ʻauwai or ʻauwai kai	Uses the shoreline as one wall	Exists only in Hawaiʻi
Loko Iʻa Kalo	X		X	X			
Loko Wai	X		X				
Loko Puʻuone	X		X			X	
Loko Kuapā	X		X			X	X
Loko ʻUme Iki		X				X	
Umu		X			X		

Adaptations/Extensions

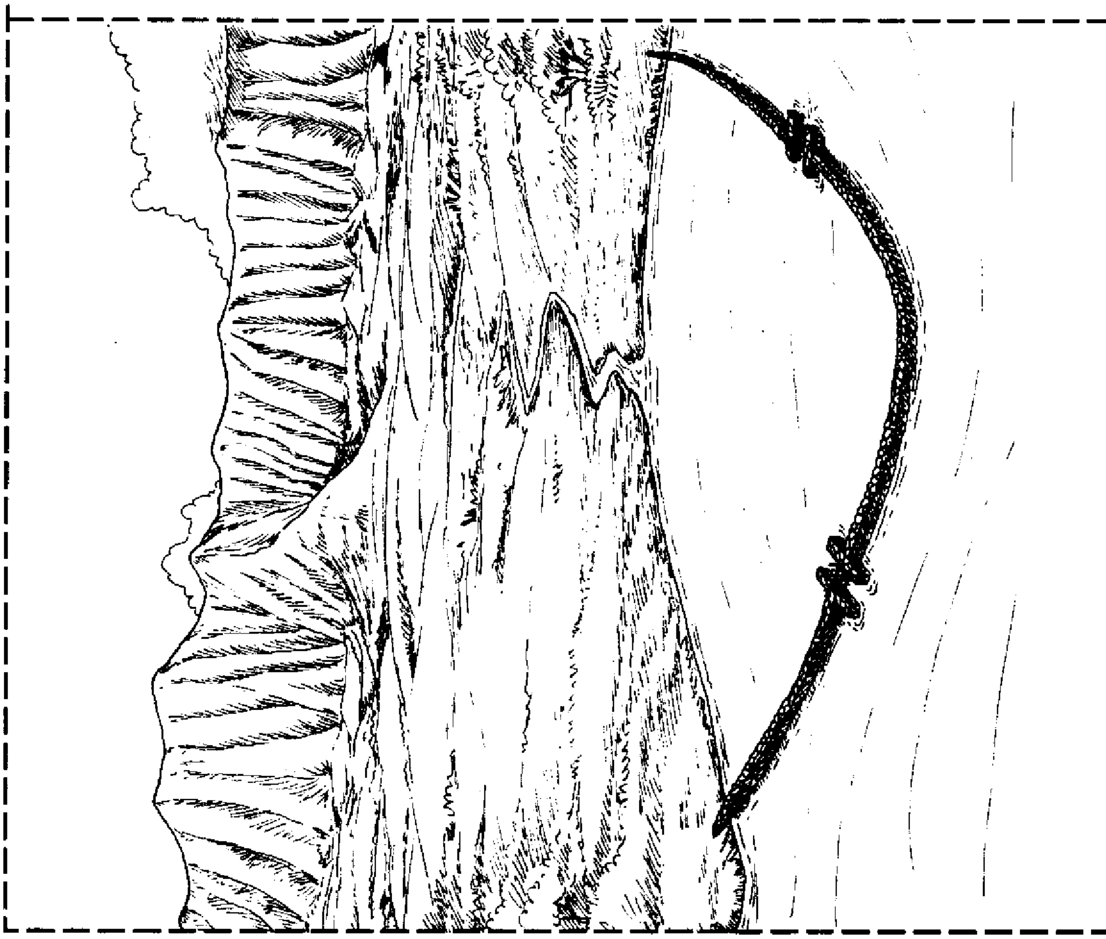
- Gather a number of pictures and illustrations of various fishponds throughout Hawaiʻi, and have the students classify each using the key features they identified for ponds in this activity.

- Ask the students to share their knowledge of fishponds located near their communities. This could include personal experiences, family history, legends, or books and articles they have read. The activity could take several forms:
  - an informal class discussion
  - a story circle (where everyone sits in a circle and each has an opportunity to speak)
  - a writing assignment, a short theme or essay
  - an art activity where the students draw pictures to illustrate a place, event, story, or personal experience

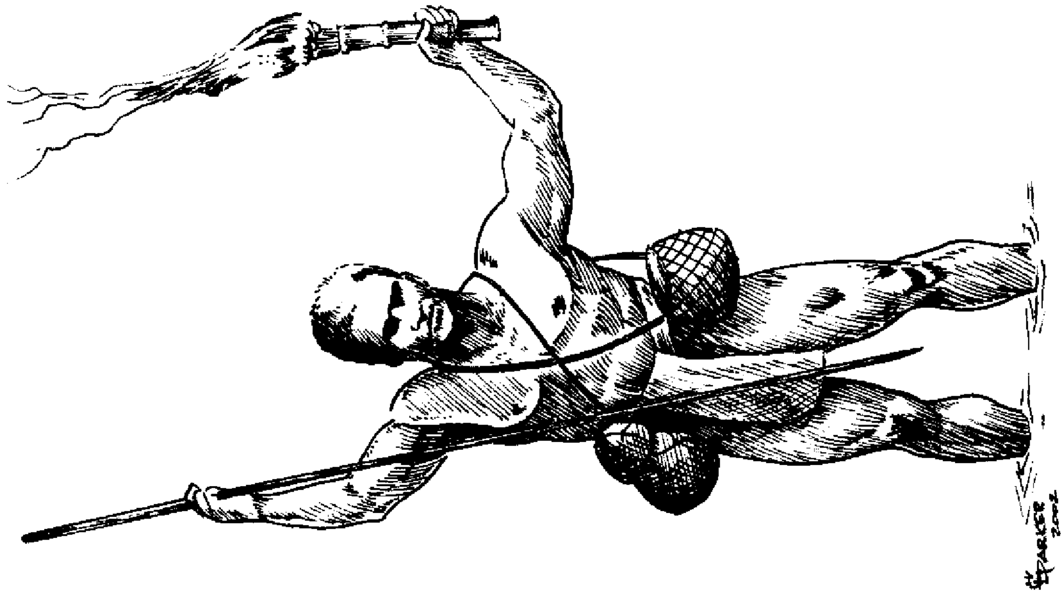
- Challenge students to create fishpond models to demonstrate how the mākāhā functions. See *Engineering Ingenuity* in Unit 3.



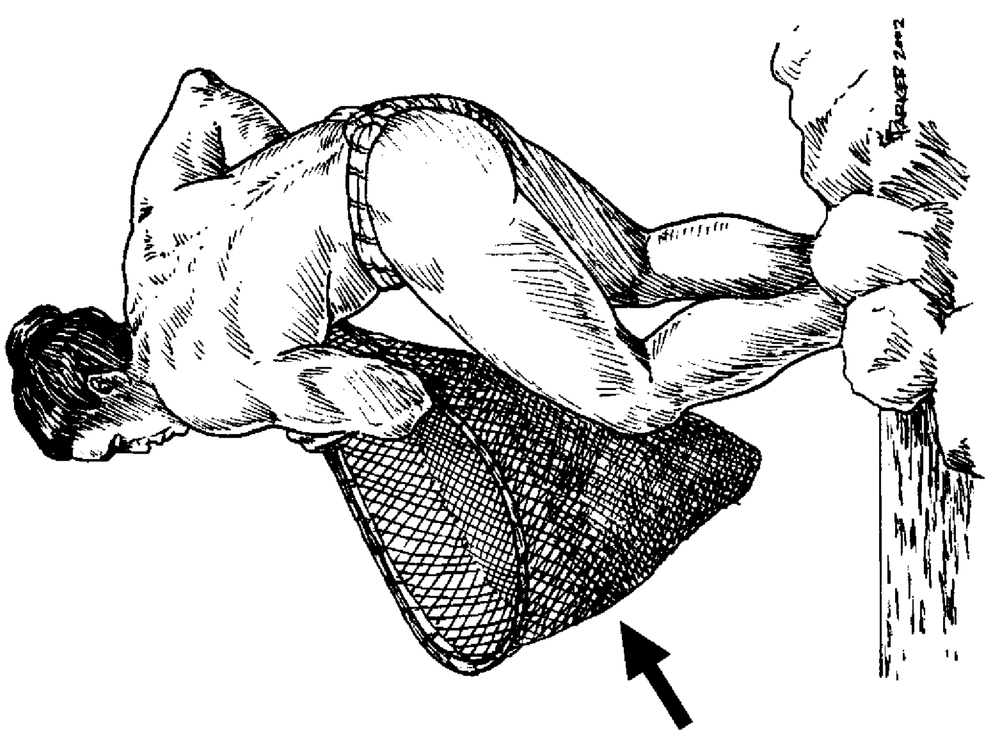
kuapā



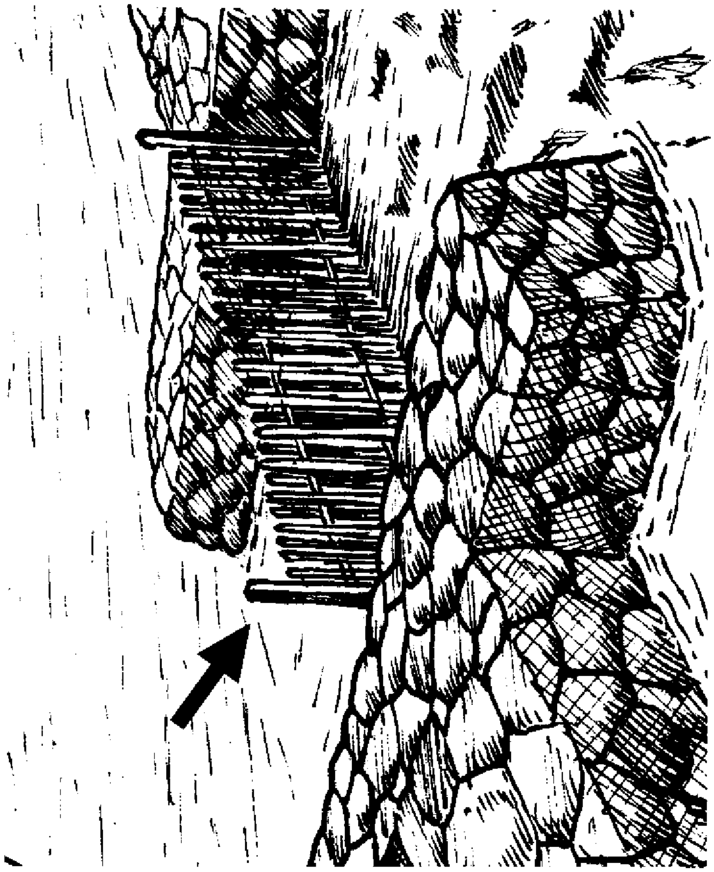
loko iʻa



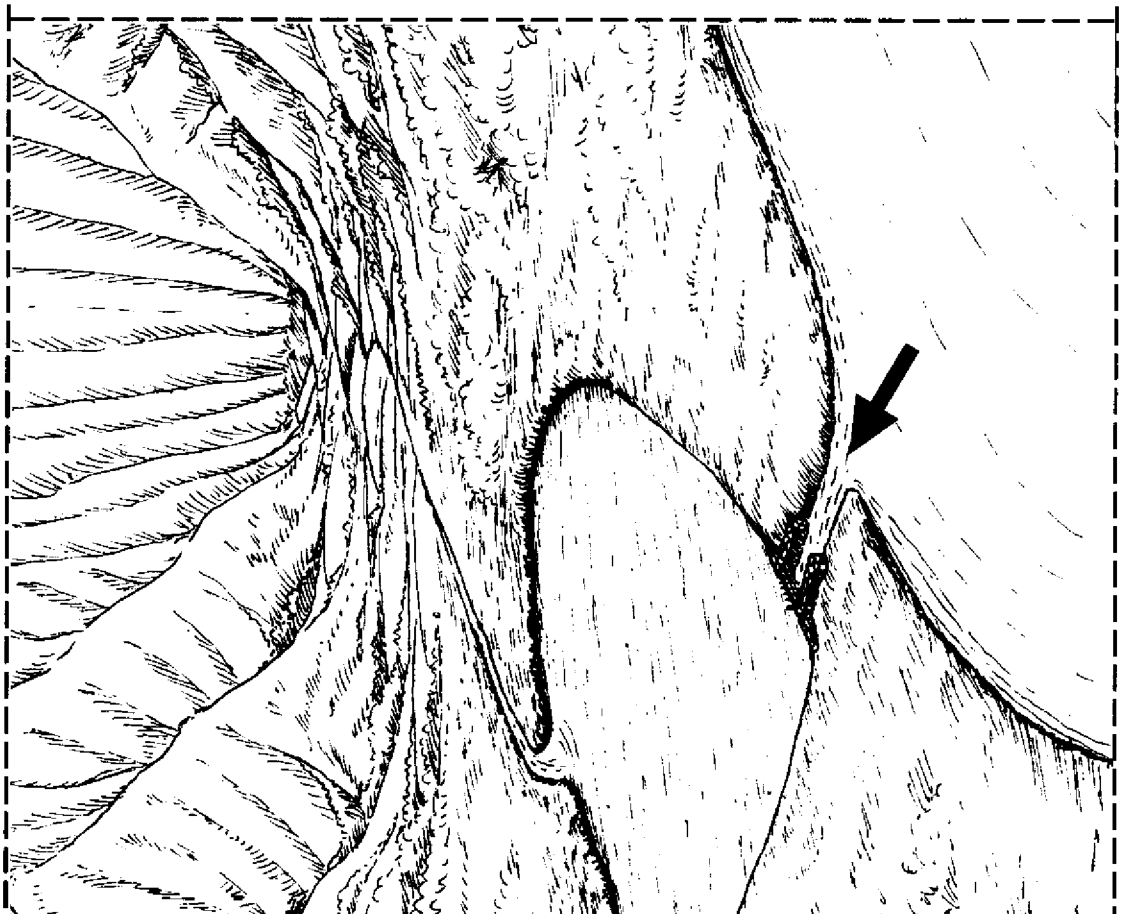
lawaiʻa



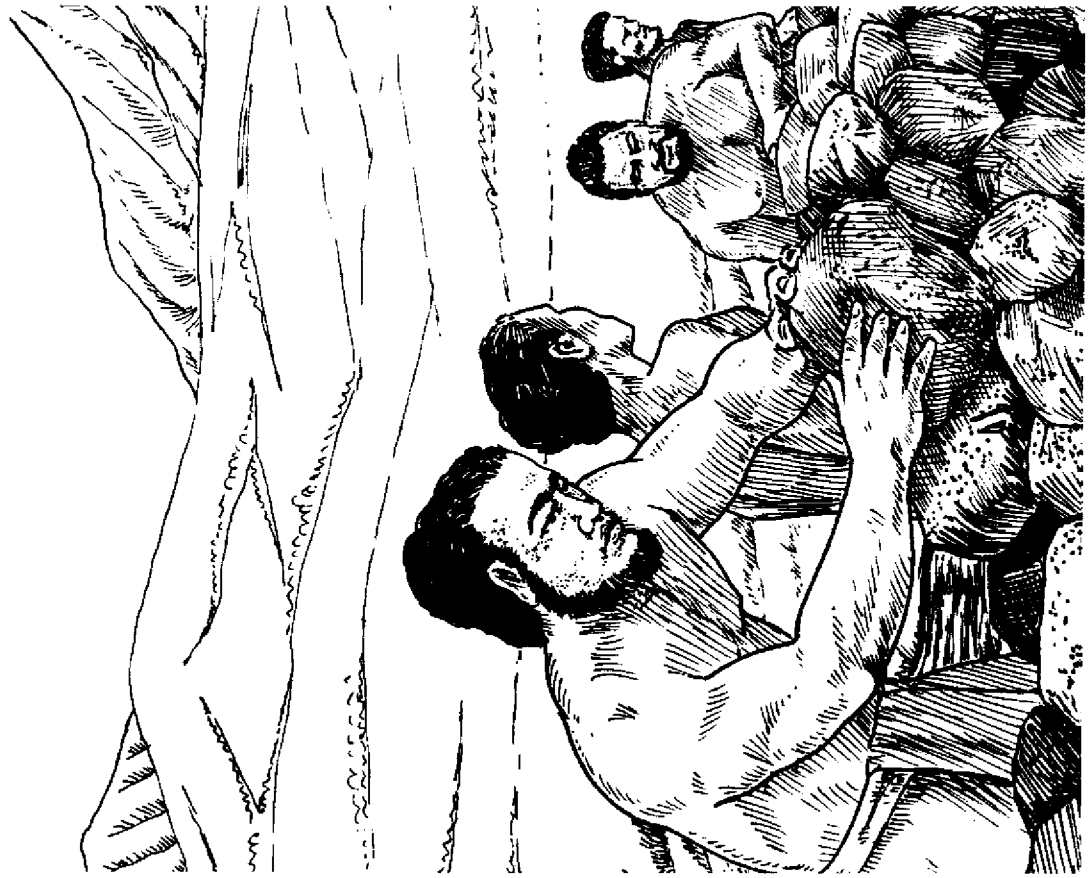
ʻupena



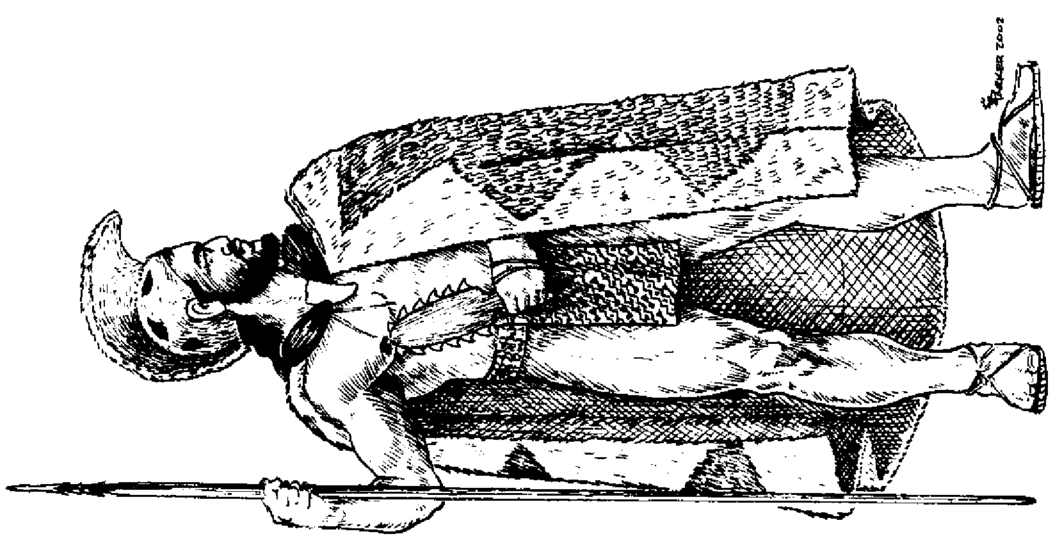
mākāhā



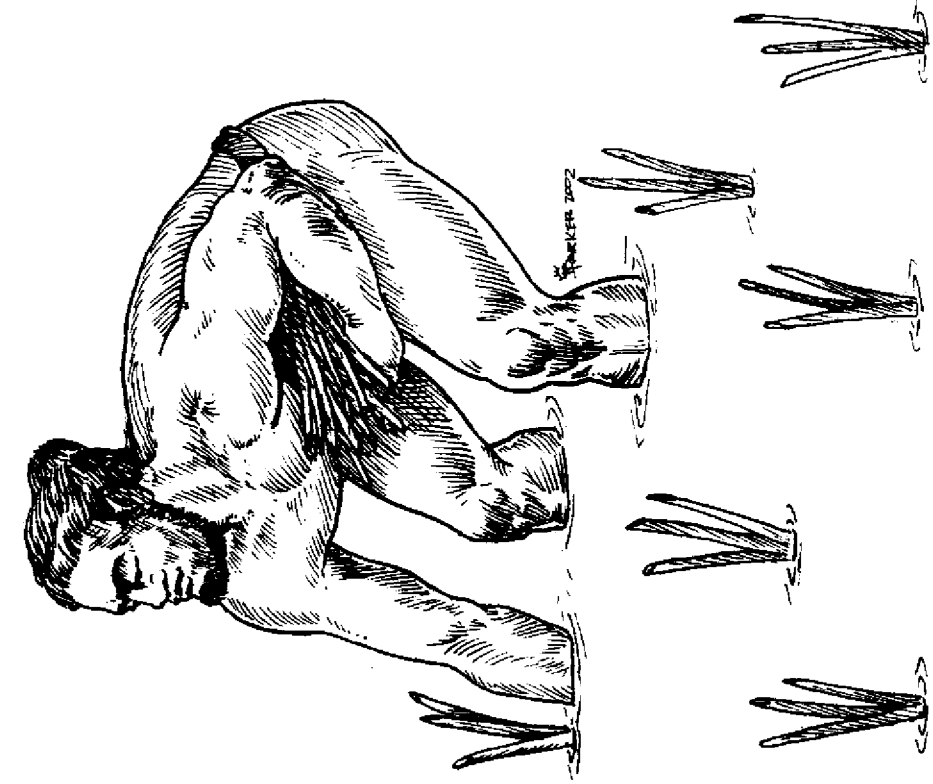
ʻauwai kai



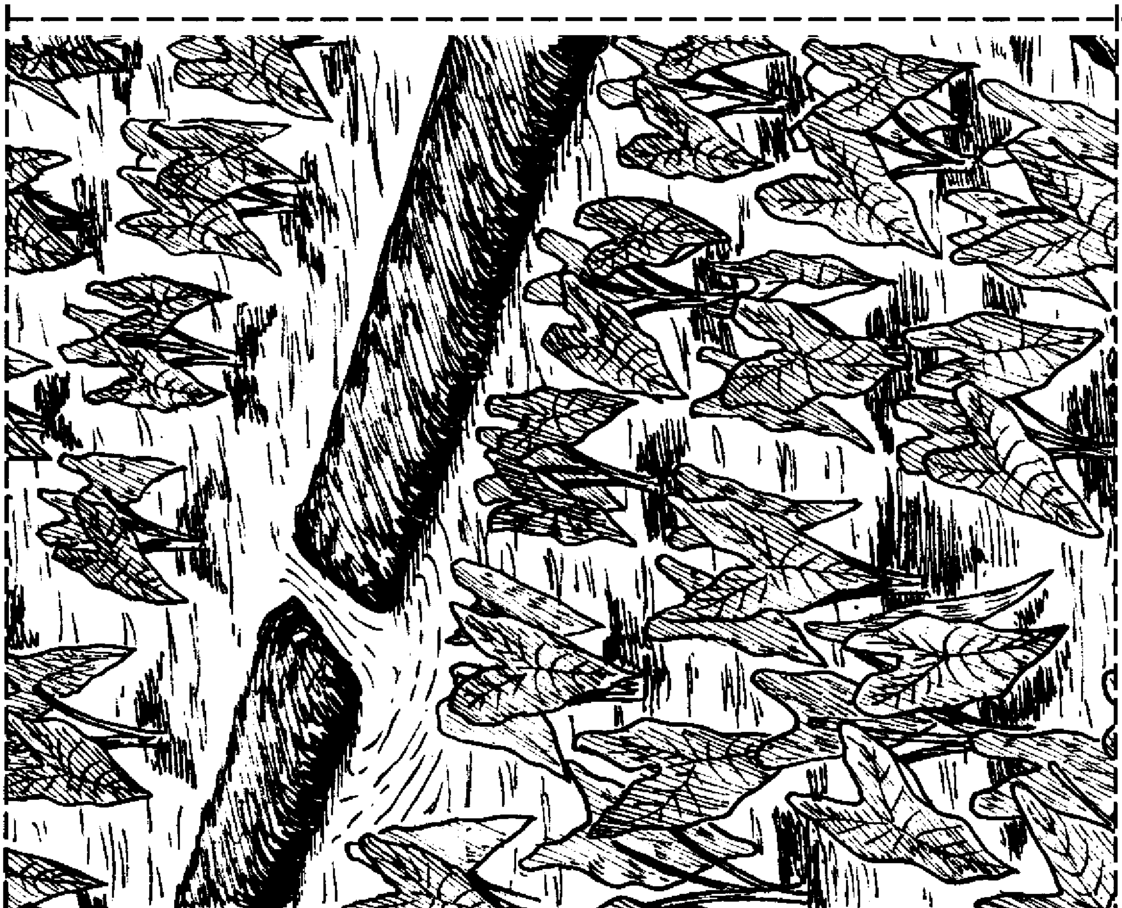
makaʻāinana



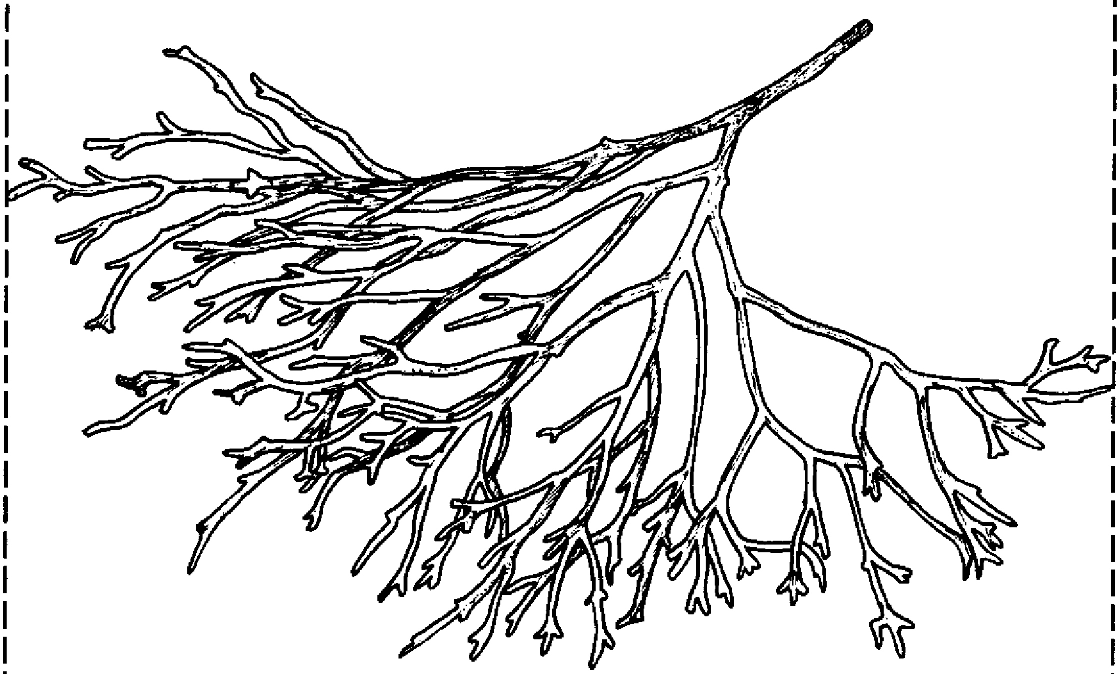
aliʻi



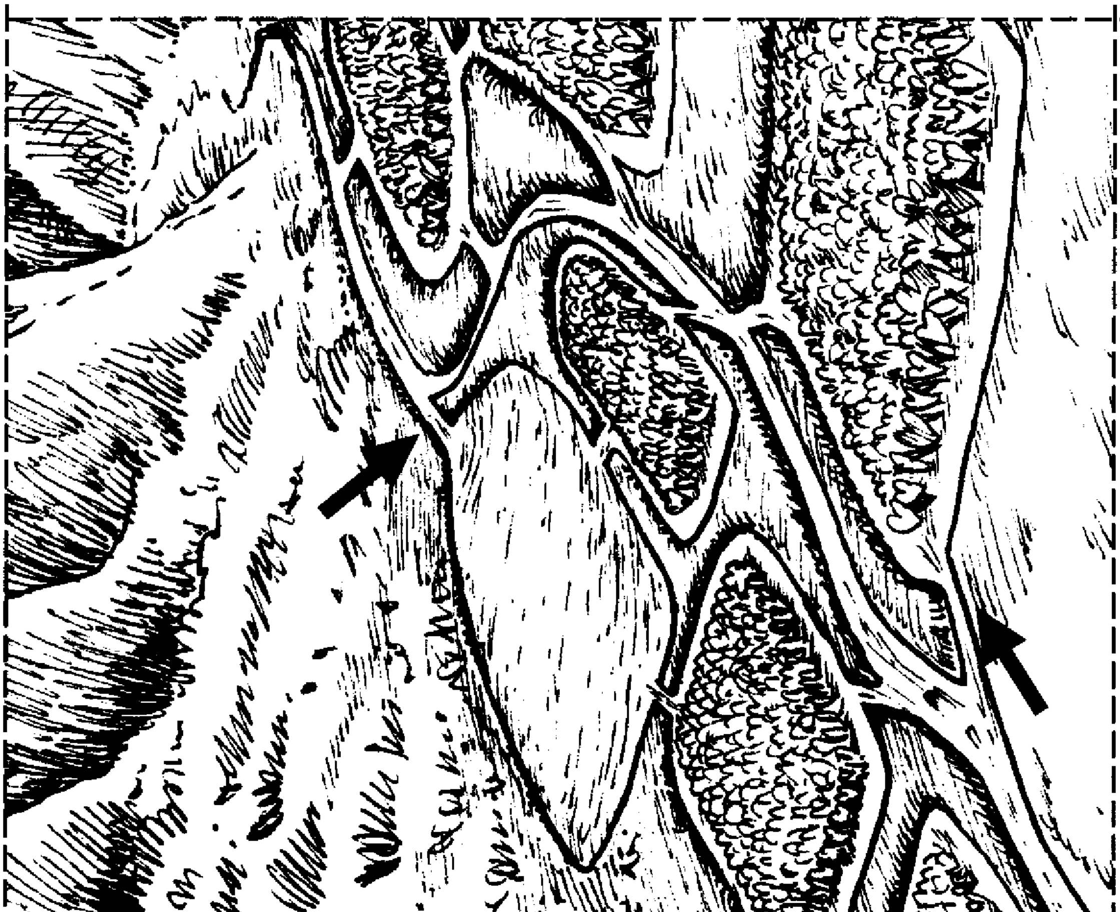
mahiʻai



loʻi



limu



ʻauwai

Loko Iʻa Kalo

Hawaiians built loko iʻa kalo (taro fishponds) in the mountains next to streams. Stream water flowed through an ʻauwai (ditch) into the loʻi (taro patches). From the taro patches the water flowed into deeper ponds. These deep ponds were used to raise fish and taro. Taro was planted in mounds of soil. Fish swam around these mounds to find food. The fish ate insects, algae, and plants that fell into the ponds. Small mākāhā (grates) kept the larger fish from escaping into the stream. The makaʻāinana (common people) harvested fish from these ponds for food.

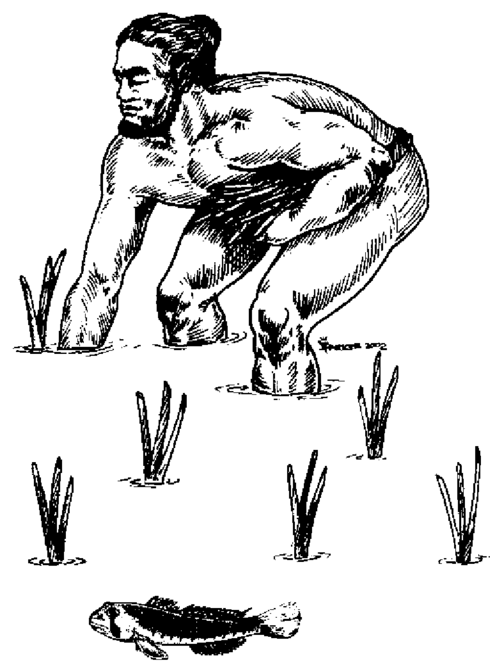
What lives in the loko iʻa kalo?

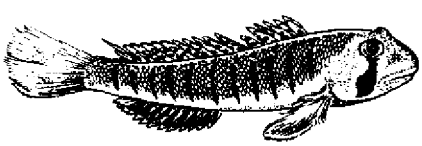
Plants

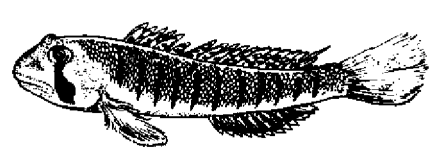
- kalo (taro)
- limu kalawai (freshwater pond algae)

Animals

- ʻoʻopu (goby)
- awa (milkfish)
- ʻamaʻama (mullet)
- āholehole (flagtail)
- ʻōpae (freshwater prawns and shrimp)

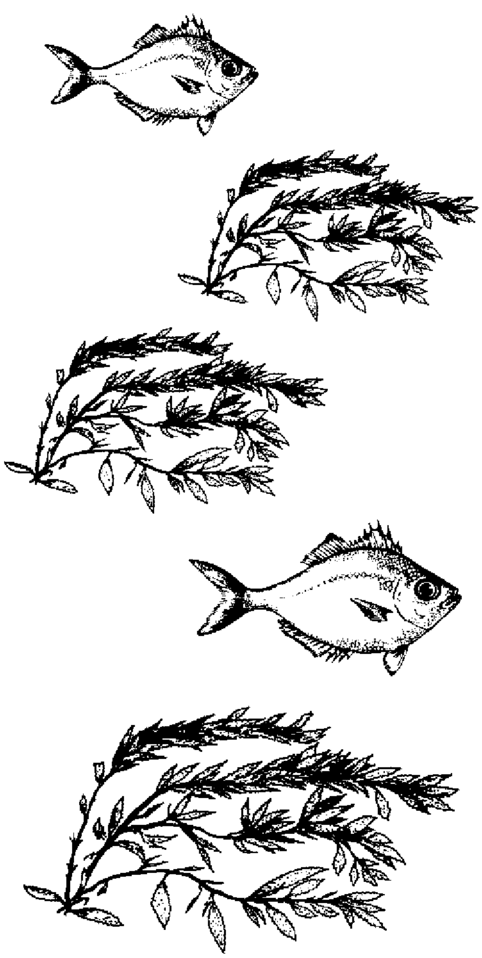






Loko Wai

Loko wai are freshwater inland ponds. Hawaiians of old made these ponds by digging out natural pools. Stream water flowed into the ponds through ʻauwai (ditches). Sometimes the ponds were built on or near natural groundwater springs. Hawaiians caught fish from the ocean, placed them in gourds filled with water, and carried them to the ponds. They put the fish in the loko wai to grow. Other animals, such as gobies and prawns, swam into the ponds from the streams. Small mākāhā (grates) prevented the larger fish from swimming back into the stream. Hawaiians harvested the fish with ʻupena (woven fish nets). They placed these nets across the channel between the pond and the stream. The fish would swim right into the ʻupena.

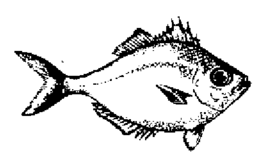


What lives in the loko wai?

Plants

- kalo (taro)
- limu kalawai (freshwater pond algae)

Animals



- ʻ oʻopu (goby)
- awa (milkfish)
- ʻamaʻama (mullet)
- āholehole (flagtail)
- ʻōpae (prawns and shrimp)
- weke (goatfish)
- awa ʻaua (ladyfish)

Loko Puʻuone

A loko puʻuone is an isolated shore fishpond named for a puʻuone (a sand dune or heap of sand) that holds water in the pond. The water in the loko puʻuone was brackish (wai kai); this means it was part salt water and part fresh water. Fresh water flowed into the ponds from springs or streams. Salt water flowed in through an opening called an ʻauwai kai. Hawaiians dug the ʻauwai kai to connect the pond to the sea. They built a mākāhā (sluice grate) at one end of the ditch. Small fish swam into the pond through openings in this grate. When the fish got bigger, they couldn't fit through the mākāhā. These trapped fish were caught for food. Some of the loko puʻuone were for makaʻāinana (commoners). Others were built for the aliʻi (chiefs).

What lives in the loko puʻuone?

Plants

- limu (seaweed)

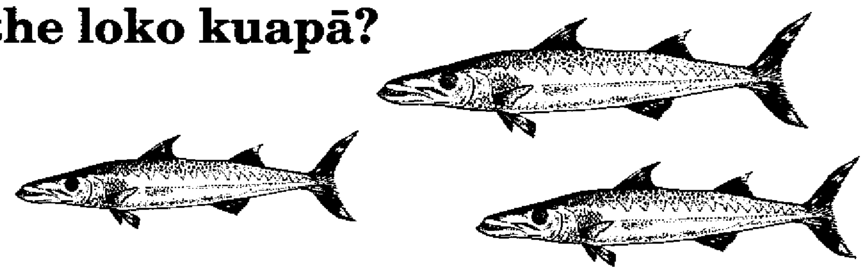
Animals

- ʻoʻopu (goby)
- pāpaʻi (crabs)
- awa (milkfish)
- ʻamaʻama (mullet)
- āholehole (flagtail)
- weke (goatfish)
- awa ʻaua (ladyfish)
- ʻōʻio (bonefish)
- pāpio and ulua (jacks)
- nehu (anchovy)
- akule (big-eyed scad)
- palani (eye-striped surgeonfish)
- pualu (yellowfin surgeonfish)
- ʻōpae (prawns and shrimp)
- ʻoʻopu hue (puffer fish)

Loko Kuapā

Loko kuapā are fishponds with kuap'ā (seawalls) built of stones and coral. Hawaiians built these fishponds on a reef flat near a freshwater stream or spring. The shoreline was the inner wall of the pond. The outer walls had openings called ʻauwai kai with mākāhā (sluice grates) that allowed sea water to flow in and out of the pond. Fish swam into the pond through the mākāhā. When the fish grew bigger, the mākāhā trapped them in the pond. Some loko kuapā had a nursery pond inside. Pua iʻi or pua iʻa (baby fish) were kept in the nursery to protect them from larger fish. Hawaiians built loko kuapā for the aliʻi (chiefs). This kind of pond exists only in Hawaiʻi.

What lives in the loko kuapā?



Plants

- limu (seaweed)

Animals

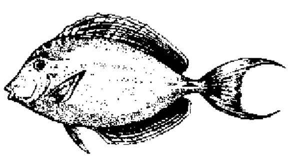
- pāpaʻi (crabs)
- ʻōpae (shrimp)
- awa (milkfish)
- ʻamaʻama (mullet)
- āholehole (flagtail)
- weke and kūmū (goatfish)
- awa ʻaua (ladyfish)
- ʻōʻio (bonefish)
- manini (convict tang)
- palani (eye-striped surgeonfish)
- pualu (yellowfin surgeonfish)

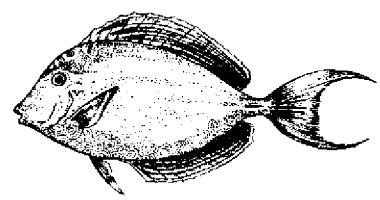
- pāpio and ulua (jacks)
- nehu (anchovy)
- akule (big-eyed scad)
- moi (threadfin)
- kākū (barracuda)
- uhu (parrotfish)
- hīnālea (wrasse)
- kāhala (amberjack)
- kala (unicorn fish)
- pūhi (eel)
- ʻoʻopu hue (puffer fish)
- nahawele (mussel)

Loko ‘Ume Iki

Hawaiians built loko ‘ume iki on the reef flats along the coast. The walls of these ponds had many funnel-shaped openings. Some of the openings were wider toward the land, and others were wider toward the ocean. The fishtrap walls had no mākāhā (sluice grates) to keep the fish from leaving. Fish were attracted to the currents created by the changing tides. Twice a day, when the tide changed, women came to gather fish. When the tide went out, fish swam into the trap. When the tide came in, fish swam out of the trap. Women placed nets across the openings to catch the fish as they swam in or out.

What is caught in the loko ‘ume iki?

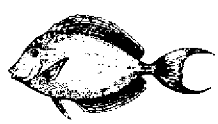




Plants

- limu (seaweed)

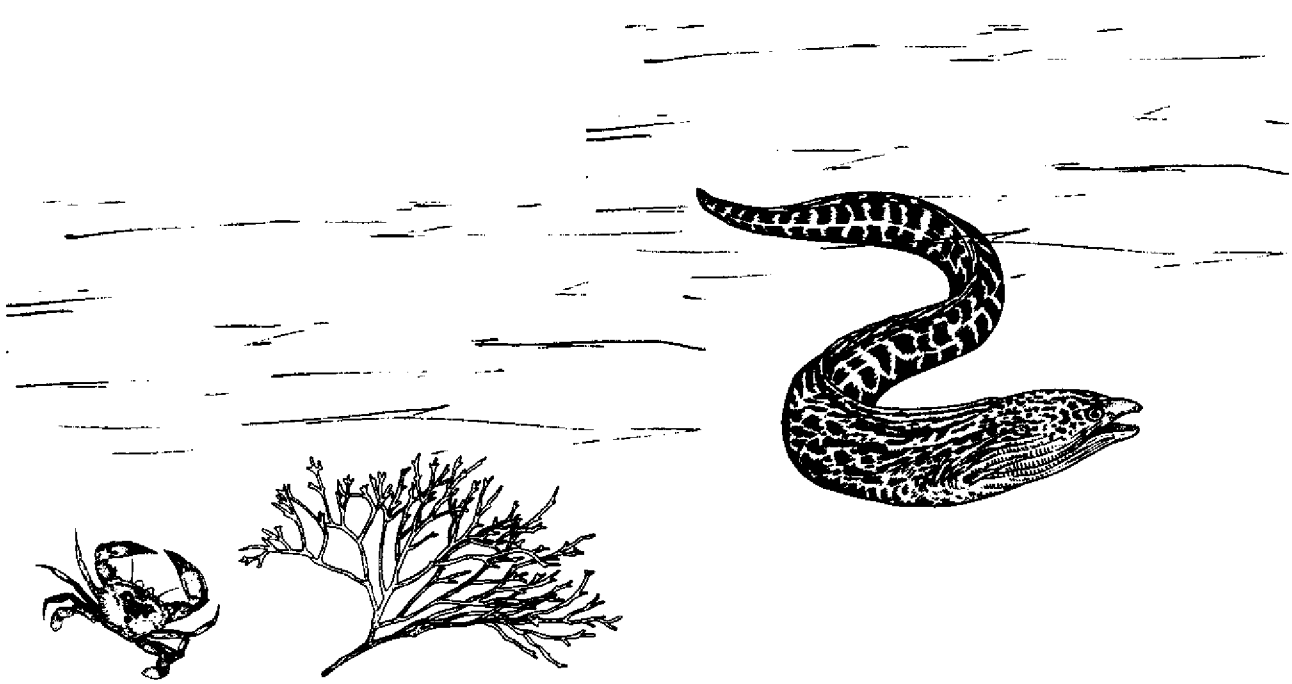
Animals

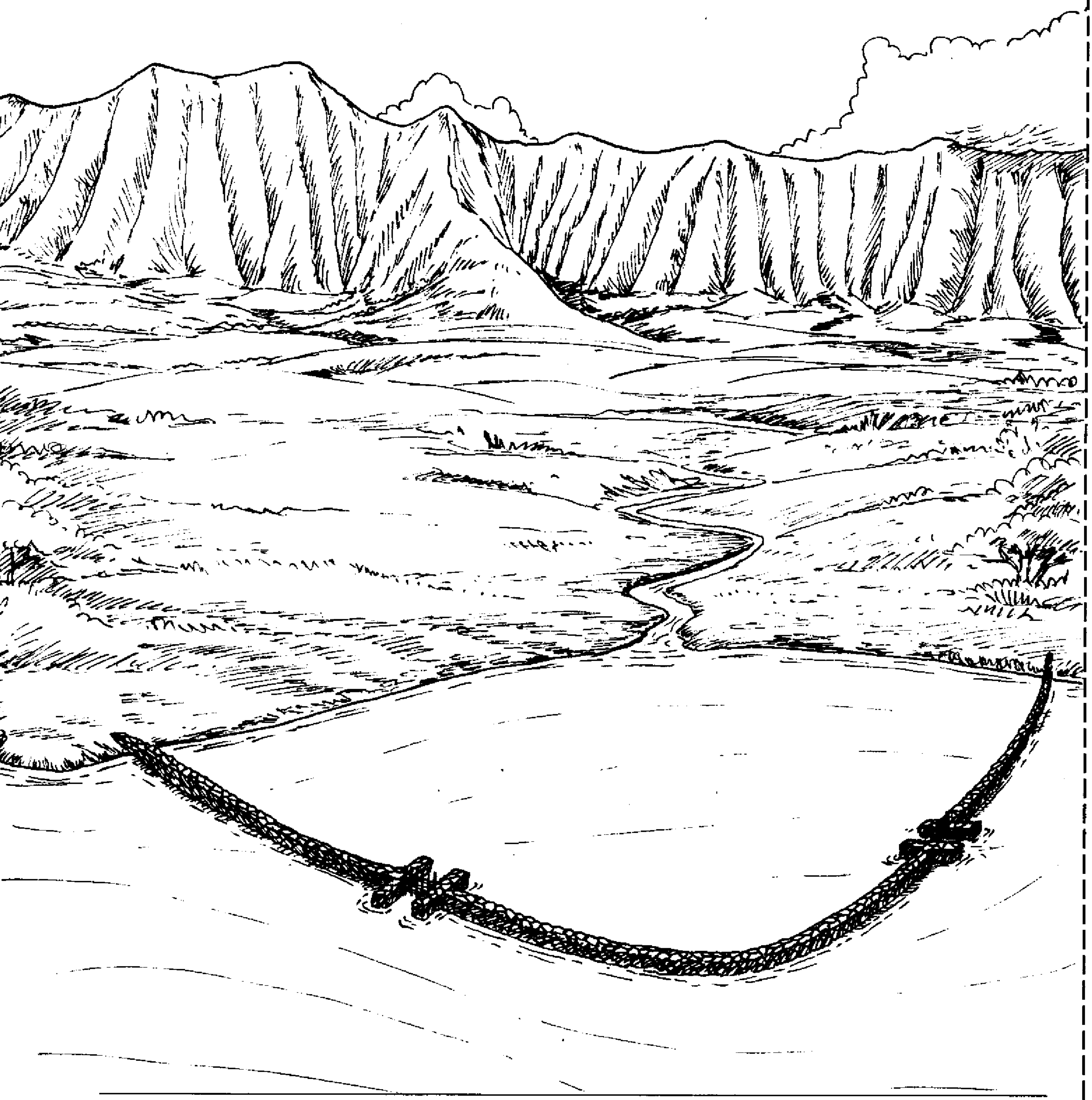


- pāpa‘i (crabs)
- ‘ōpae (shrimp)
- awa (milkfish)
- ‘ama‘ama (mullet)
- āholehole (flagtail)
- weke and kūmū (goatfish)
- awa ‘aua (ladyfish)
- ‘ō‘io (bonefish)
- pāpio and ulua (jacks)
- nehu (anchovy)
- akule (big-eyed scad)
- moi (threadfin)
- kākū (barracuda)
- uhu (parrotfish)
- hīnālea (wrasse)
- kāhala (amberjack)
- manini (convict tang)
- palani (eye-striped surgeonfish)
- pualu (yellowfin surgeonfish)
- kala (unicorn fish)
- pūhi (eel)

Umu

Umu (heap of rocks) are small underwater "houses" that trap fish. Hawaiians made these traps by piling stones loosely into a mound. Seaweed grew on the surface of the stones and that attracted the fish. Water flowed through the umu and fish would hide inside. Women caught fish by placing a woven net over the opening on one side while shaking a palm frond or stick along the other opening. The fish inside the umu would swim away from the stick or palm and into the net. Sometimes an eel would enter the umu and scare the little fish away. The women would then catch the eel for food. Soon little fish would return to the umu to hide in the rocks. Umu were not permanent fishtraps. People today still use this method to trap fish.



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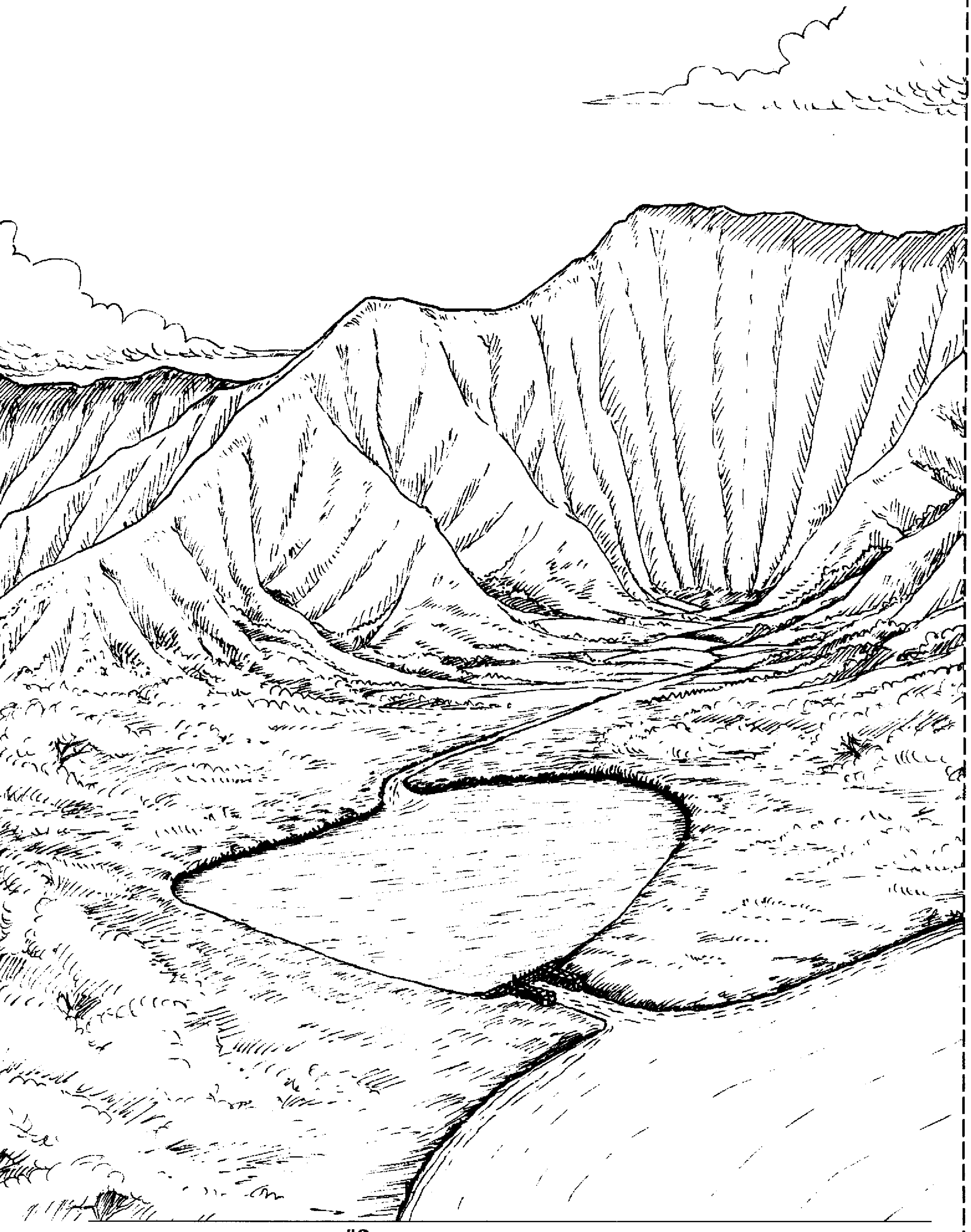

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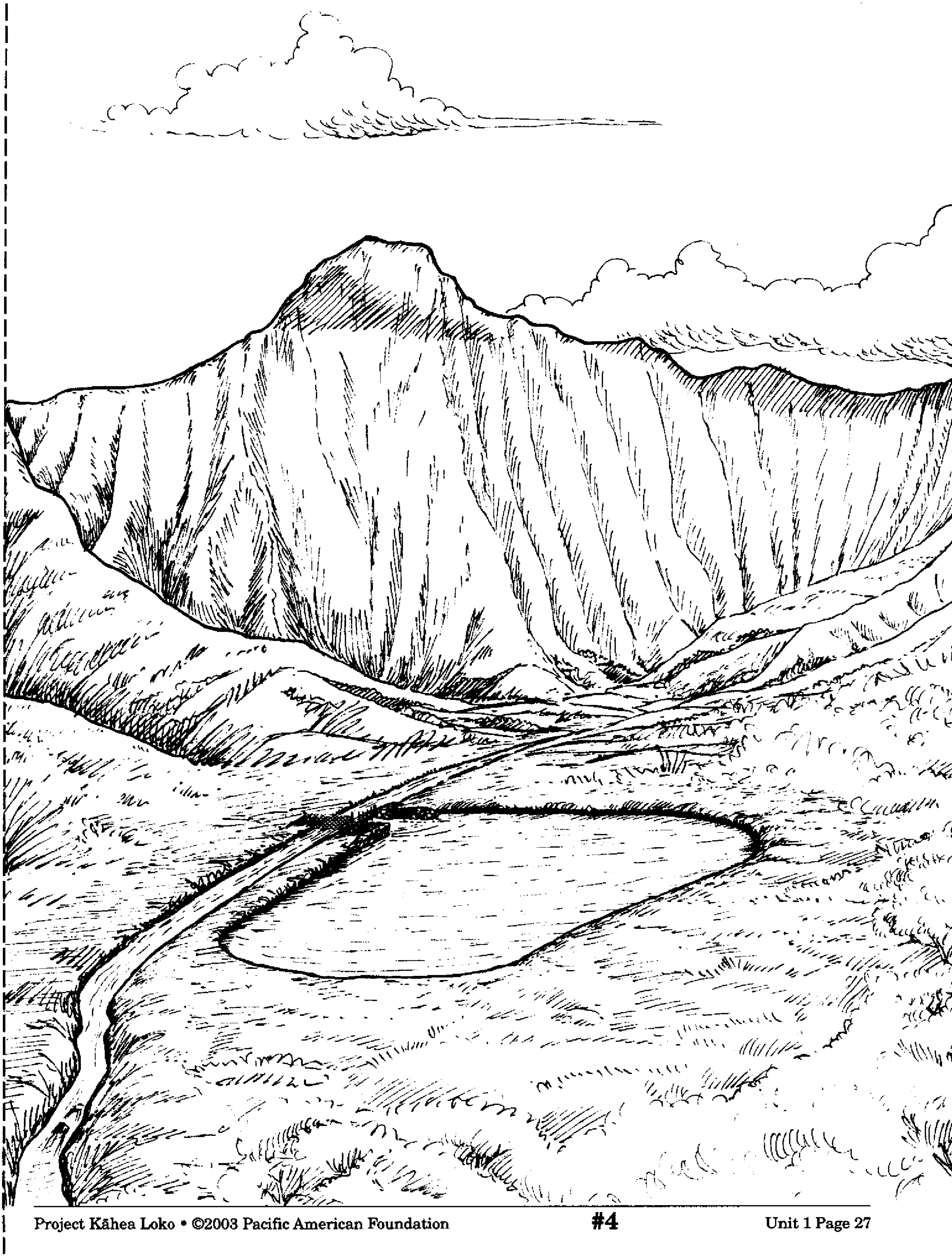
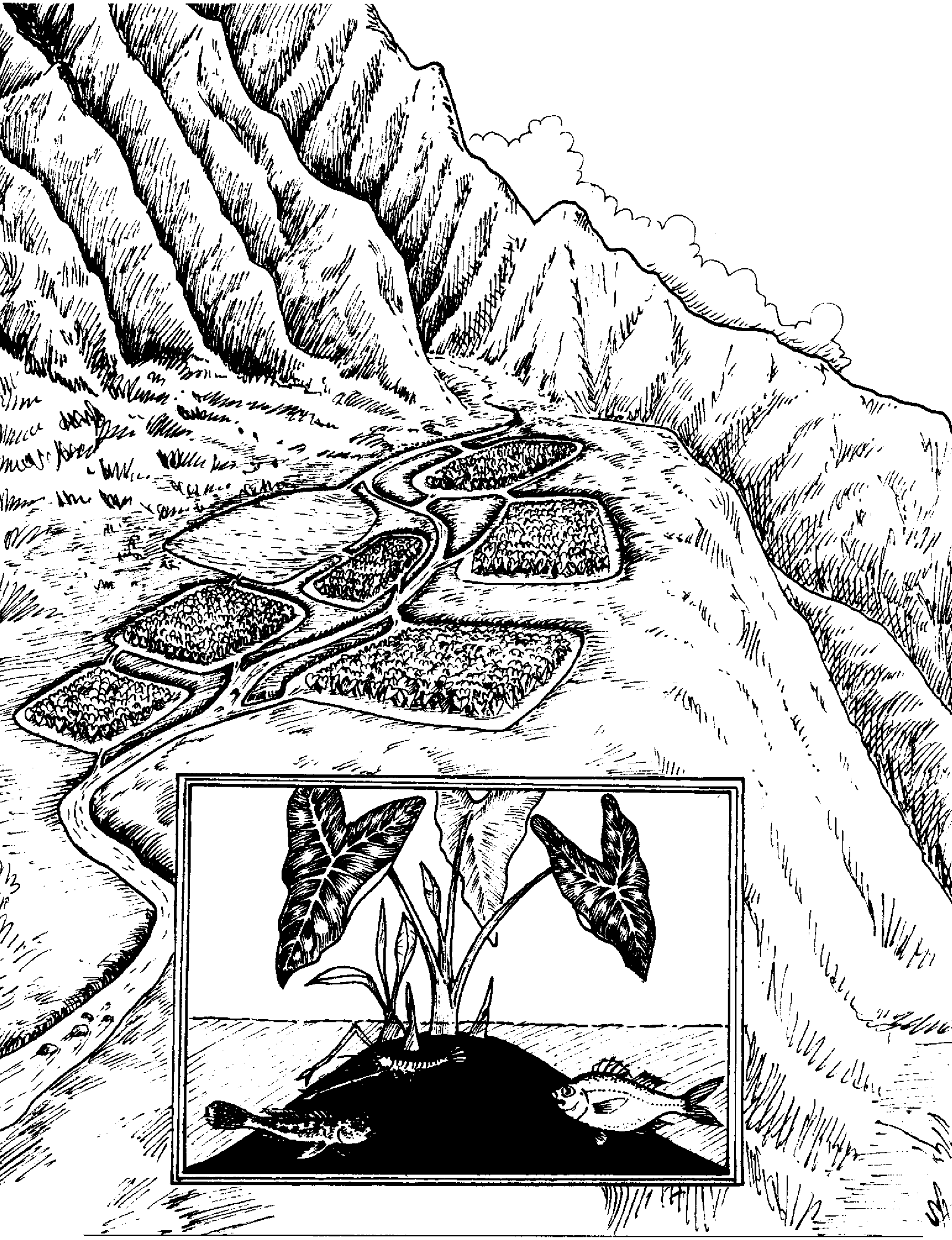
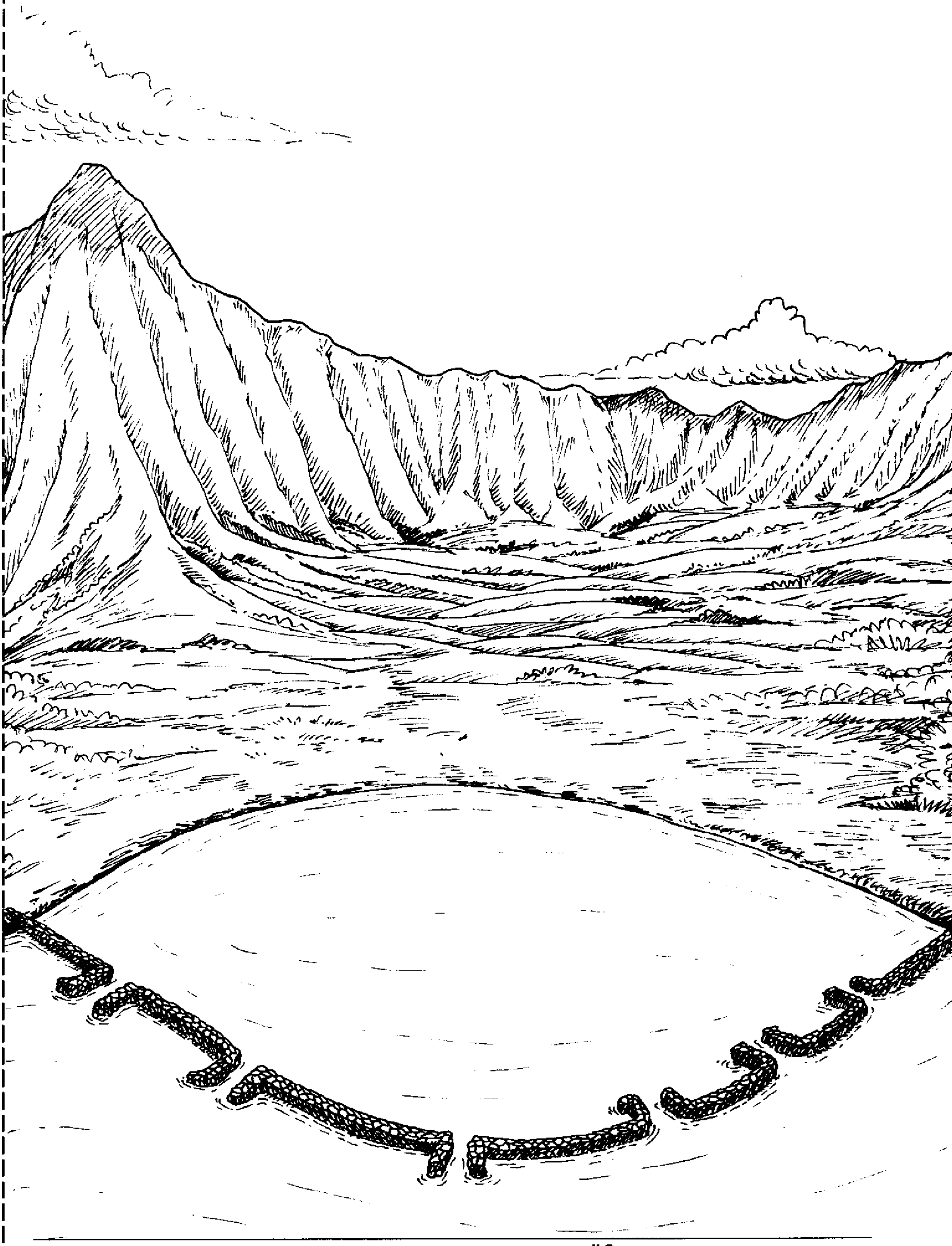
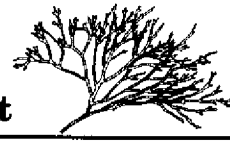




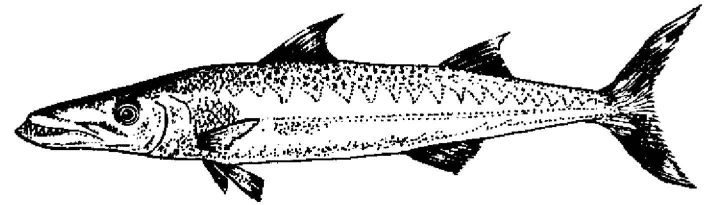


Student Activity Sheet

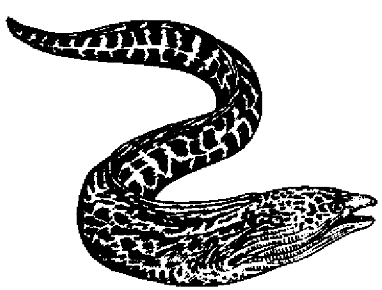


Name ____________________

List the four types of fishponds and two types of fishtraps in the first column. Then make an "X" in each box that describes something about that pond or trap.



Type of fishpond or fishtrap	Uses mākāhā	Used only to trap fish	Fed by streams or springs	Used for growing kalo	Has no 'auwai or 'auwai kai	Uses the shoreline as one wall	Exists only in Hawai'i



On the back of this sheet write a brief summary comparing the different types of fishponds and fishtraps in Hawai'i.

Mauka to Makai: The Ahupuaʻa

- How did physical features within an ahupuaʻa determine where Hawaiians built different types of fishponds and fishtraps?

Hawaiʻi DOE Content Standard

Social Studies: Geography – World in Spatial Terms

- Students collect, organize and analyze data to interpret and construct geographic representations.

Grades 4 – 5 Performance Indicators

- Show organization of collected data.
- Construct a map that includes collected geographic data.
- Explain the meanings, patterns and relationships found in geographic data.

Key Concepts

- Ahupuaʻa (traditional Hawaiian units of land) vary in shape and size and the distribution of geographic features.
- Hawaiians built different types of fishponds to take advantage of existing geographic features within an ahupuaʻa. These features include the flow of water, natural depressions in the land, reefs, bays and sand bars.

Prerequisite

Loko Iʻa

Activity at a Glance

Students create a large mural that illustrates where Hawaiians built different types of fishponds and fishtraps to take advantage of geographical features within an ahupuaʻa.

Ahupuaʻa Mural
Kāneʻohe Elem. Gr. 4

Time

3 - 4 class periods

Skills

reasoning, analysis, mapping

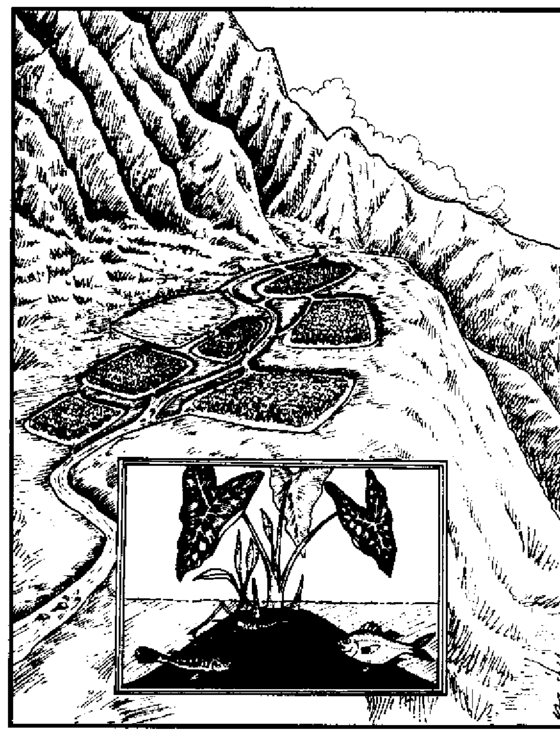
Assessment

Student groups:

- Create a section of an ahupua'a mural that depicts one type of fishtrap or fishpond with labels of the physical features that are important for that type of pond or trap.
- Present their section of the mural to other students in the school.

Vocabulary

ahupua'a – traditional Hawaiian land unit usually extending from mountain summits to outer edge of reefs
kai – sea water
kula – plains; open country
uka – upland, towards the mountain
moku – land district
mauka– toward the mountain
makai– toward the sea



Materials

Provided:

- fishpond illustrations (from *Loko I'a*)

Needed:

- round loaf of sweet bread
- knife with serrated edge (to cut bread)
- large butcher paper for mural
- construction paper
- colored markers
- scissors
- glue

Advance Preparation

Line up the six illustrations of fishponds and fishtraps (see *Loko I'a*) from mauka to makai and post them in the classroom.

Teaching Suggestions

1. Place a round loaf of sweet bread in front of the class and ask students to imagine that it is a mountainous island surrounded by ocean. Ask them what kind of resources, such as fresh water, soil and forest, this island would need if people were to live on it. Discuss how people might share those resources.

2. Cut the bread into pie-shaped wedges from the top of the bread (mauka) to the edge (makai). Define an ahupua'a. Explain that this section of the island might be a valley with valley walls delineating its boundaries. Cut additional wedges of varying widths from the bread and discuss why some ahupua'a might be smaller than others.

3. Display the illustrations from the *Loko I'a* activity and ask students to point out the physical features in the different parts of the ahupua'a. Ask students to imagine that they lived in an ahupua'a like this in old Hawai'i and discuss their ideas. During the discussion, add students' ideas to the K-W-L chart created in the previous activity and write in the types of fishponds or traps that they believe would be located in different areas of the ahupua'a.

   <u>Discussion Questions</u>
   - What are the main physical features in the upland (uka) region of this ahupua'a? *(mountains, stream)*
   - What are the main physical features in the middle (kula) region? *(stream, relatively flat areas)* Which types of fishponds did Hawaiians build here? Why?
   - What are the main physical features in the coastal (kai) region? *(bay, sandbar, reef flat)* Which types of fishponds and fishtraps did Hawaiians build here? Why?
   - If you lived in this ahupua'a in old Hawai'i, where would you build your hale (house)? Why?

4. Explain that these illustrations make up an idealized ahupua'a and that most ahupua'a might have the physical resources to support only one or two types of fishponds, if any. Compare this idealized ahupua'a to the ahupua'a where your school is located. What are the similarities and differences?

5. Challenge the class to create a large color mural of an ahupua'a that includes all six types of fishponds and fishtraps. Divide the class into six 'ohana (family) groups, refer to the fishpond illustrations, and assign tasks:

   - 'Ohana 1 and 2: create the uka part of the mural and the kula area with a loko i'a kalo ('ohana 1) and a loko wai ('ohana 2).
   - 'Ohana 3 – 6: create the kai region of the ahupua'a with each group working on one of the remaining fishponds or fishtraps.

6. When the mural is complete, have the class develop a presentation to share the mural with other classes. Ask each 'ohana to present its fishpond or fishtrap and show how it is dependent on the physical features in that section of the ahupua'a.

7. Revisit the K-W-L chart from the *Loko I'a* lesson and fill in statements and questions for each category.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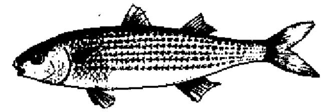
Unit 1 at a Glance



Grades 6 - 8

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: World in Spatial Terms Interpret and construct geographic representations to explain human and physical distributions and patterns.	**1C.** What are the similarities and differences between traditional fishing and land use patterns on atolls in the Marshall Islands versus the high Hawaiian Islands? **Activity: *Pacific Patterns: Traditional Fishing and Land Use***	• Traditional fishing practice and land use patterns on a Marshall Islands atoll are similar to those on a high Hawaiian Island, despite the greater availability of fresh water and other resources on a high island. • Fishtraps rely on the receding tide for trapping fish within stone enclosures. Fishponds are a true form of aquaculture where fish are grown and raised to maturity within enclosures. • Fishtraps were common in the Pacific, but fishponds were constructed nowhere as extensively as in Hawai'i. • The extensive development of fishponds in Hawai'i compared to other areas of the Pacific may have been due to several factors including the physical resources—protected bays and estuaries, extensive coastal reefs and streams; and human innovation and resources—large populations with highly organized social structure.	Students: • Create geographic representations based on the readings to illustrate traditional fishing and land use patterns in a Marshall Islands atoll and a high Hawaiian island. • Write a summary that: - describes any elements of the stories that are similar to students' personal experiences; - compares and contrasts patterns of land and water use in the wato and ahupua'a; and - compares past practices to present day fishing and land use patterns.
Science: Using Unifying Concepts and Themes (MODEL) Identify several different models that could be used to represent the same thing, and evaluate their usefulness, taking into account such things as the model's purpose and complexity. **Social Studies: Places and Regions** Use physical and human characteristics to compare and analyze major world regions, countries, and cities.	**1D.** How are fishtraps different from fishponds? What factors might have led to the extensive development of fishponds from fishtraps in Hawai'i compared to other areas of the Pacific? **Activity: *From Fishtraps to Fishponds***		Students: • Create models of fishtraps and demonstrate how they work • Develop hypotheses to explain physical and human factors that might have led to the extensive development of fishponds in Hawai'i compared to other areas in the Pacific.

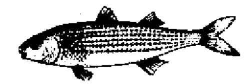
Culminating Activity

Students conduct research to support their hypotheses about why there was extensive development of fishponds in Hawai'i compared to other areas of the Pacific. Their research papers should show cause and effect between factors that may have led to the extensive development of fishponds in Hawai'i and include: 1) key events and/or people, 2) physical factors, and 3) human factors.

Note: If students' research contradicts their hypotheses, they should write their conclusions based on what they have learned. Direct students to suggested references listed at the end of this unit.

Review criteria for assessing students' writing and have them work with you to develop a rubric (see sample rubric below). Ask students to share their hypotheses with one another and discuss what they learned from their research. For additional information on this topic, see the background information in the activity *From Fishtraps to Fishponds.*

Sample Rubric for Culminating Activity



Performance Indicators	Kūlia Exceeds Standard	Mākaukau Meets Standard	'Ano Mākaukau (Almost at Standard)	Mākaukau 'Ole (Below Standard)
Social Studies: Places and Regions Show evidence of the physical and human characteristics of world regions, countries or cities. *Points* ____	Writing shows evidence of both physical and human characteristics that may have led to extensive fishpond development in Hawai'i and offers new insights.	Writing shows evidence of both physical and human characteristics that may have led to extensive fishpond development in Hawai'i.	Writing shows evidence of only physical or human characteristics that may have led to extensive fishpond development in Hawai'i.	Writing does not show evidence of physical or human characteristics that may have led to extensive fishpond development in Hawai'i.
Use data to compare the regions, countries or cities. *Points* ____	Uses substantial data and cites references to compare evidence in Hawai'i with physical and human characteristics in Micronesia or another area of the Pacific.	Uses sufficient data and cites references to compare evidence in Hawai'i with physical and human characteristics in Micronesia or another area of the Pacific	Uses limited data to compare evidence in Hawai'i with physical and human characteristics in Micronesia or another area of the Pacific.	Does not include data to compare evidence in Hawai'i with physical and human characteristics in Micronesia or another area of the Pacific.
Writing Conventions (grammar, punctuation, spelling, capitalization, paragraphing) *Points* ____	Skillful use of conventions; writing is easy to read and fluid.	Minimal errors; writing shows skillful use of writing conventions.	Frequent errors make writing difficult to understand; more work needed on writing conventions.	Many errors make writing difficult to understand; more work needed on writing conventions.
Organization of Ideas *Points* ____	Ideas are skillfully organized and logically sequenced to communicate well.	Ideas are logically sequenced and organized to communicate well.	Ideas are not well organized so writing is difficult to follow.	Ideas are not organized; writing is unclear.
Content Depth *Points* ____	Content is in-depth and develops more complex ideas.	Content is presented effectively; goes beyond facts and details to develop ideas.	Content is valid but offers little depth or elaboration.	Content is lacking in information and/or accurate information.

Pacific Patterns:
Traditional Fishing and Land Use

- What are the similarities and differences between traditional fishing and land use patterns on atolls in the Marshall Islands versus the high Hawaiian Islands?

Hawai'i DOE Content Standard

Social Studies: World in Spatial Terms

- Students use geographic representations to organize, analyze, and present information on people, places, and environments.

Grades 6 - 8 Performance Indicators

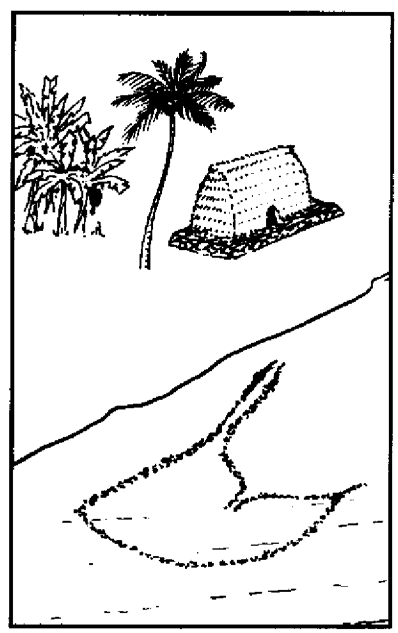
- Make geographic representations that show title, directional indicators, and legend or key.
- Plot distribution of physical features.
- Explain patterns drawn from the distribution data.

Key Concept

- Traditional fishing practices and land use patterns on a Marshall Islands atoll are similar to those on a high Hawaiian Island, despite the greater availability of fresh water and other resources on a high island.

Activity at a Glance

Students read stories, compare traditional fishing and land use patterns on two Pacific islands, and create geographic representations of what they have learned.



Time

2 - 4 class periods

Skills

reading comprehension, reasoning, writing, mapping

Assessment

Students:

- Create geographic representations based on the readings to illustrate traditional fishing and land use patterns on a Marshall Islands atoll and a high Hawaiian island.

- Write a summary that:
  - describes any elements of the stories that are similar to students' personal experiences;
  - compares and contrasts patterns of land and water use in the wato and ahupua'a; and
  - compares past practices to present day fishing and land use patterns.

Vocabulary

atoll – a roughly circular reef surrounding a broad lagoon
fishtrap – a structure for trapping fish
estuary – the lower part of a stream where the current meets the tide of the ocean
wato – a land management system used in the Marshall Islands of Micronesia
ahupua'a – a traditional Hawaiian land unit usually extending from mountain summits to the outer edges of reefs
pā – a primitive type of fishtrap that has a single lane to guide fish at low or high tide, but not at both

Materials

Provided:
- student readings
- student activity sheets

Needed:
- map of the Pacific
- reference materials (optional: see suggestions at end of unit)

Advance Preparation

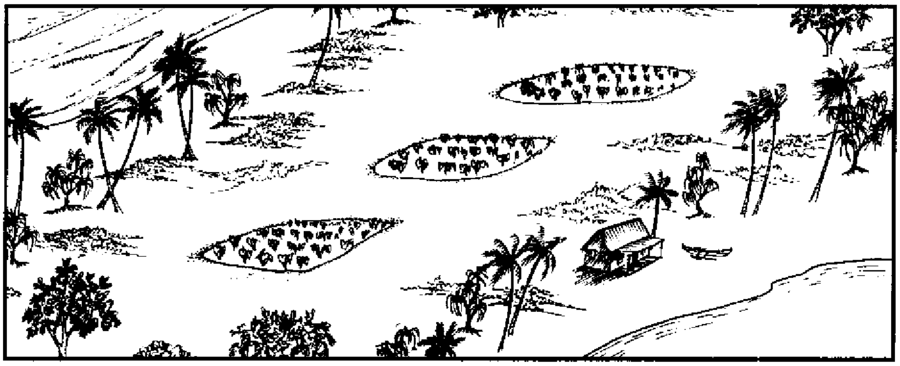
Make a copy of the student readings and activity sheet for each student. Optional: Gather some of the reference materials and check with the school librarian to see what other resources may be available to students.

Background

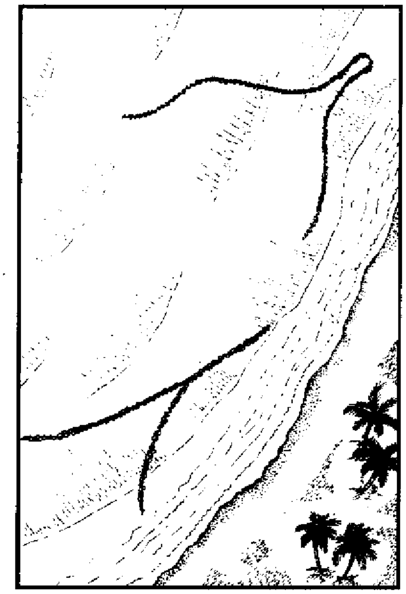
Traditional fishing knowledge of Pacific islanders has been acquired and passed down over centuries of studying fish responses to tides, currents and habitats. Methods of catching fish are as innovative and as varied as the colorful patterns that make up the myriad of fish found on tropical Pacific reefs. In Pacific island communities, men traditionally have been responsible for catching most of the fish, using spears, bone and shell hooks, many types of nets, and lures as well as walled fishtraps. Women still gather shellfish and seaweed and catch small fish in nearshore waters. Methods of trapping fish and sharing land resources are similar among the different Pacific island groups:

Polynesia: the islands of the central and south Pacific Ocean including Hawai'i, the Line Islands, Phoenix Islands, Tonga, Cook Islands, and Samoa Islands, Tuvalu, Easter Island, French Polynesia, and often New Zealand

Melanesia: the islands in the Pacific Ocean northeast of Australia and south of Micronesia including Bismarck Archipelago, the Solomon, Vanuatu, New Caledonia, and the Fiji islands



Wato (Marshallese land division). Adapted from Spennemann, Dirk H.R., 1998. Essays on the Marshallese Past. Second Ed., Albury, Australia.

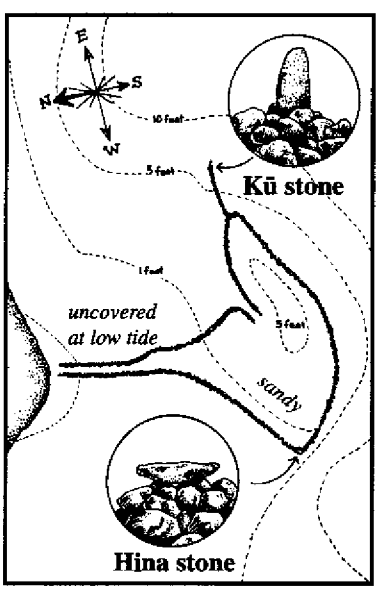


Fishtraps in the Marshall Islands – stone walls are submerged at high tide and fish swim freely; when the tide goes out, fish swim along the walls with the receding tide and become trapped behind threshold stones.

Micronesia: the islands of the western Pacific Ocean east of the Philippines and north of Melanesia including the Caroline, Kiribati, Mariana, and Marshall groups

The thousands of low islands in the Pacific are made of coral; many are coral atolls. Natural resources on these islands are mainly confined to the ocean.

On the coral atolls of the Marshall Islands are some of the most highly skilled fishers in Micronesia. Fishing is vital to survival on land-poor atolls that have thin topsoil, no rivers, and reach only 14 feet above sea level. Traditional ways of managing the limited land resources and using innovative techniques for trapping fish have helped the Marshallese to sustain themselves for centuries. The reading for students provided with this activity describes the traditional wato (Marshallese land division) and the large stone-walled fishtraps that are still used on some of the islands today (Spennemann, 1998).



Fishtrap (pā) from Pu'uloa, O'ahu. The first fish caught was offered to Kū'ulakai, the god of fishing, represented by a Kū stone.

On high volcanic islands, like the Hawaiian Islands, the soils are richer and rainfall is greater than on atolls. The fertile soils and greater rainfall sustain more agriculture, but subsistence fishing was still a vital part of early Hawaiian life. Like the Micronesians, Hawaiians managed their resources within traditional land units. These land units, known as ahupua'a, generally extend from the mountain summit to the edge of the reef. The ahupua'a provided the people with most of the resources they needed for survival.

Where conditions were suitable, Hawaiians constructed walled fishtraps to take advantage of currents and tides to trap fish. The stone-walled fishtrap described in the student reading, the pā, is similar to fishtraps found throughout the Pacific. Pā are a primitive type of fishtrap that have a single lane to guide fish at low or high tide, but not at both. The general V-shape and the height of the stone walls are designed to trap fish with the outgoing tide.

Hawaiian fishtraps and fishponds included stones to represent gods associated with fishing. The Kū stone represented Kū'ulakai, the god of fishing, who some say had control over all the other gods of the sea. When he died, one of the gifts he left for his son, Ai'ai, was a magic stone called Kū'ula, which had the power to attract fish. The son traveled about the Islands and set up fishing altars upon which to lay two fish from the first catch, one for his father, Kū'ula and one for his mother, Hina (Beckwith, 1970). The Kū stone was placed in an upright position on the eastern side of the fishpond. The Hina stone, representing Kū's wife, lay flat on the western wall of the fishpond. At the fishponds, a small pile of coral or stones was erected where fish were offered in ceremony to Kū'ula by the kahuna (priest). The kahuna would call upon [Kū or] Hina to draw the fish from the sea and into the pond. If the fish tried to escape, they would sense Kū'ula's presence and fear leaving the pond. If they tried to make their way over the wall of the pond, the stones – representing men – would prevent them from escaping (Wyban, 1992).

Teaching Suggestions

1. Display a picture of an atoll (photographs are available on the Web at http://hawaiianatolls.org) and ask students to comment on how living on an atoll would be different from living on their island. Discuss the differences in elevation above sea level at the islands' highest points (for example, 14 feet on the atoll versus 4,000 – 13,000 feet on the high island); availability of resources in forests, streams, groundwater, and reefs.

2. Distribute the student readings and the student activity sheet. Have students read them together aloud in class or as a homework assignment. Ask students to complete the activity sheet summarizing similarities and differences between the two island groups.

3. Using a map of the Pacific, ask students to find Majuro and Ajola in the Marshall Islands of Micronesia and the Hawaiian Islands in Polynesia. Review students' activity sheet answers.

Discussion Questions

- What were the similarities and differences between the physical settings and traditional land divisions in the Marshall Islands and Hawaiian Islands?
  (Similarities: both are Pacific islands with tropical reefs; Differences: atolls are much smaller and lower; they have no streams, less rainfall and limited groundwater.)

- How is the wato similar to the ahupua'a? How is it different?
  (Both land divisions provided access to resources needed for survival and included some of the same plants, especially cultivated taro. The wato is much smaller and is designed to meet needs of a smaller population. Taro is grown in depressions fed by groundwater instead of cultivated terraces fed by streams.)

- How did the traditional fishing practices and fishtraps in the Marshall Islands compare to the practices and traps in Hawai'i?
  (Both areas practiced some form of torch fishing and stunning fish with plant extracts; fishtraps were of similar designs.)

- How were the lifestyles similar?
  (Fishing was vital to survival; men were principal fishers; women and girls collected shellfish and limu near shore.)

4. Ask students to create geographic representations of a wato and ahupua'a based on the readings. Have students plot the physical features and major plant communities in these land management systems using the activity sheets provided or a blank page. Their work should include:

   - a legend or key identifying the major plant communities
   - directional indicators (mauka – makai or lagoon – seaward)
   - highest elevation
   - outlines of fishtraps in the areas where they were built.

   Note: students could use Kid Pix to draw the diagrams and HyperStudio to present them. See examples of completed geographic representations provided below.

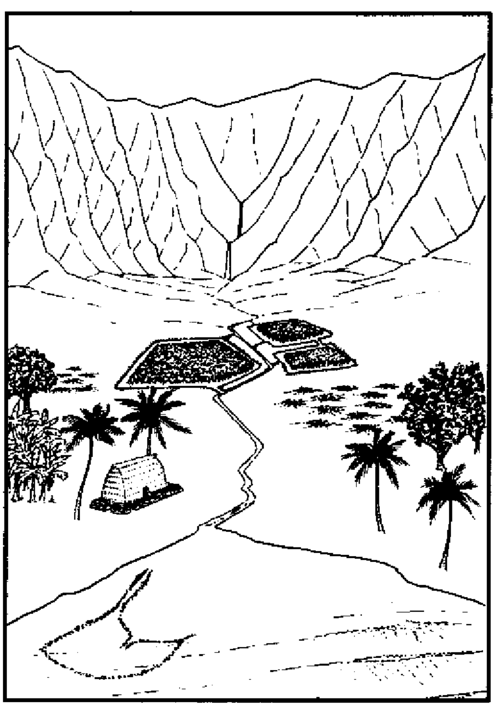
5. Ask students to complete the written assessment activity and share their ideas with their classmates.

Adaptations/Extensions

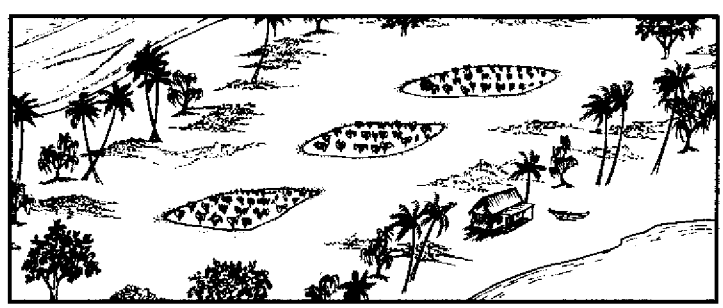
- Have students conduct some research and write their own stories depicting life in the day of an islander fishing on Majuro or O'ahu today. Have them analyze some of the changes that have taken place and the impact of moving from a subsistence to a market economy.

- See the activities in Unit 3 to explore what has happened to Hawaiian fishtraps and fishponds over time.

Examples of completed geographic representations.



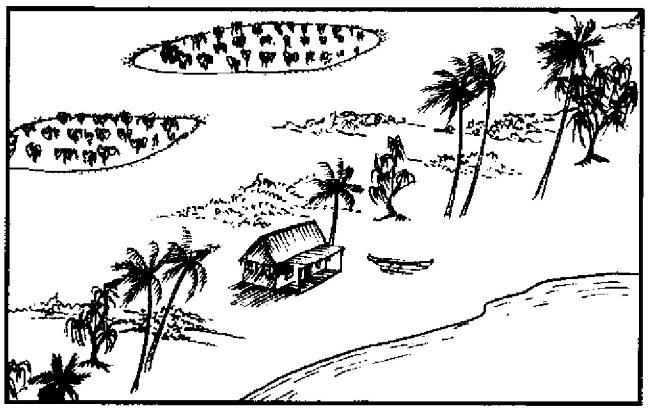
Hawaiian ahupua'a.



Marshallese wato.

Student Reading — A Day on Majuro Island

It's early morning on Majuro Island. The year is A.D. 1400. Giltamag yawns and stretches, watching the still waters of the lagoon. He's still a little tired from torch fishing last night with his father. Giltamag likes fishing at night. It's exciting to paddle their canoes out in the water on a dark, moonless night with only a coconut frond torch to guide the way. Flying fish are attracted to the torch light and Giltamag and his father caught some in their nets. It was a good catch; his mother is pleased.



Giltamag's father is a great fisher, respected by everyone in the village and on islands nearby. He passes on his knowledge to his son, grateful that Giltamag learns so quickly. Giltamag has mastered the art of stupefying fish. He's learned to use an extract from the wop plant to stun the fish and make them easier to catch. He's shown his skill at fishing by the light of the moon, catching mon, the big-eyed squirrelfish that uses its big eyes to find food at night. By the time the moon is full again, Giltamag will have helped the islanders rebuild the stone fishtraps that were damaged in last week's storm out on the reef flat.

Heading for the reef, Giltamag and his father cross the family's traditional wato—their narrow land allotment that runs across the island from the lagoon to the ocean shore. In this wato, the family members have access to all of the different resources they need. Behind their thatched home, they walk through breadfruit trees that provide them with food and wood. They step over twigs and branches that were blown down in the storm. This is the highest point on the island, about 14 feet above sea level.

In the center of the island they pass the family's taro patch. They grow taro in a small pit where the plants' roots can reach the atoll's limited groundwater lens. There are no streams and there is little rainfall. Growing near the taro there are *Pandanus* (hala) trees that help to shelter the taro from salt spray. Women on the island weave the *Pandanus* leaves into mats and baskets. Walking on, Giltamag grins when he sees his cousin, Yanmog, coming out of his house to join them. Together they run through the coastal forest of *Pandanus* trees and *Scaevola* (naupaka) shrubs, past the coconut palms, heading for the beach. They jump over the large coral cobbles that have washed ashore and cool their feet in the ocean.

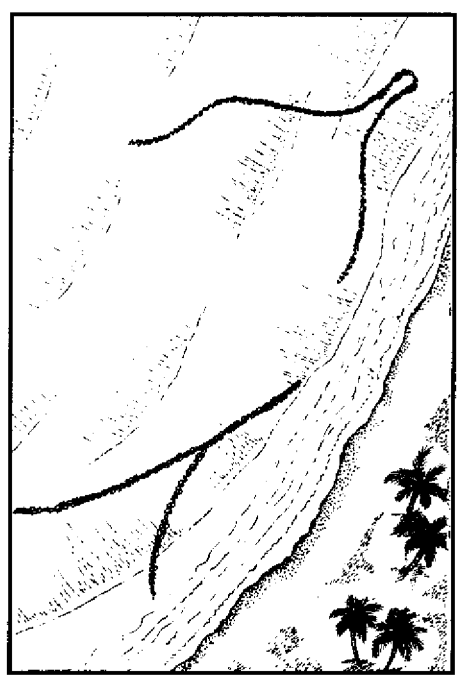
Other islanders are gathering on the beach to join them. Giltamag and Yanmog watch the girls gathering seaweed and shellfish in the shallow water. They share some coconut milk with them as they prepare for the work ahead. Looking across the water to Ajola Island, they can see the rocks of six long fishtraps just above the receding tide. Big waves from the storm have knocked down many coral stones that make up the traps. Giltamag and Yanmog race each other to the first fishtrap, Giltamag struggles for breath, swimming behind his older, faster cousin. They peek behind them and see the girls laughing from shore.

Then the work begins. The boys grab the coral cobbles from the ocean floor and hand them to their fathers who rebuild the long V-shaped walls of the fishtraps. It's hard work, but working together, they slowly make their way to the tip of the "V." Here the boys learn to rebuild a small, circular enclosure where the fish will be trapped. They watch the men place the stones just high enough so that the high tide will cover them and the fish will swim freely. They place a large "threshold" stone at the tip of the "V" that will help to trap the fish. When the tide goes out, the fish swimming next to the walls for cover will be trapped inside these circular enclosures, unable to escape over the stones.

The boys continue down the other wall of the trap, retrieving fallen stones and helping their fathers to rebuild. When they finally reach the end, their muscles are aching but they are smiling, looking forward to the next full moon when they will return to help with the harvest. Then the tide will be at its highest and lowest heights and the boys will participate in the kottoor—the practice of driving fish into the trap. Now they are eager to get home, but too tired to race for shore.

Waving to his cousin, Giltamag heads back across the island with his father. When they reach home, they can see the orange setting sun reflected in the lagoon. They are greeted by the delicious smell of taro and flying fish cooking. Giltamag will sleep well dreaming of fish coming into the trap, girls laughing on the shore, and Yanmog swimming breathless as he tries to catch up to *him* on the reef.

Aerial photographs of fishtraps from Majuro and Ajola are available on the Web. Go to: http://marshall.csu.edu.au/html/culture/Fishtraps.html.



V-shaped stone fishtraps – stone walls are submerged at high tide and fish swim freely; when the tide goes out, fish swim along the walls with the receding tide and become trapped behind threshold stones.

Student Reading A Day in Honouliuli on O'ahu

Kapono and his younger sister, Pua, step out of their thatched hale (house) to greet the dawn. This is the day they've been waiting for. The moon will be full tonight and the tide will be very low by mid-afternoon. The conditions are just right for a big fish catch. Kapono and Pua live near the shore of Pu'uloa, a beautiful area that will become known as Pearl Harbor some day. It is A.D. 1650 in Honouliuli—the largest ahupua'a (traditional land division) on the island of O'ahu. From the outer edge of the reef to the forested mountain summit approximately 2,000 feet high, this ahupua'a provides the families that dwell in Honouliuli with the resources they need for their survival.

Kapono stretches his sore muscles. Yesterday, he and his father had walked mauka (toward the mountain) where they worked in the family's lo'i kalo (taro patch). They had to repair the walls of the 'auwai (ditch) that diverts water from Honouliuli Stream into their lo'i. They had cared for the ulu (breadfruit) and mai'a (banana) growing near the stream. At the end of the day, they harvested kalo and made their way downslope to their home near the sea. Along the way, they stopped to harvest some 'uala (sweet potato) growing in plots nearby. In this dry, hot plain, the 'uala grows in natural sinkholes that retain some water after a rain.

Pua helps her mother clean the kalo and 'uala, but she never takes her eyes off of Kapono. Pua loves the sea and wishes she could spend more time learning to fish on the reef like her brother. He has learned from his father how to use extract of the 'ākia plant to stun fish and catch them. He has even learned to fish at night! One dark moonless night, Pua followed her father and brother to the beach and watched them catch i'ao (silversides)! From her perch on the shore, she could see the lights of her brother's coconut frond torch as he moved along the reef edge, attracting the fish. Today, she knows where Kapono is headed and she isn't going to be left behind. When their cousin Keoni shows up, Kapono and his father take up their nets and head for the beach. Pua jumps up and runs to join them.

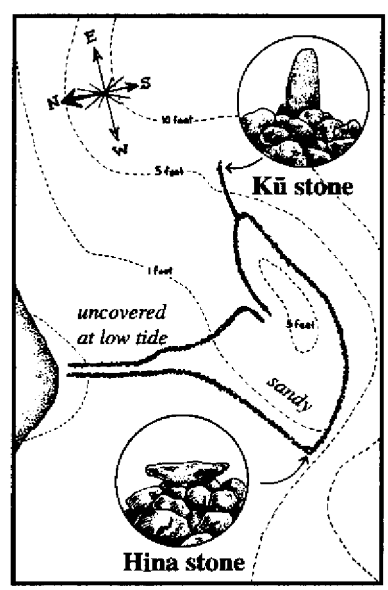
They are fortunate to live near the shores of Pu'uloa. Here there is an estuary (the area where the stream meets the incoming tides) and the waters are rich in fish, shrimp and pipi (pearl oysters). Pua's father tells them that the pipi were gifts from Kānekua'ana, the akua mo'o (royal lizard) that guards the area. The people believe that when the akua mo'o is pleased with them, there will be plenty of fish and shellfish. Hopefully, today will be such a day.

Kānekua'ana should be pleased. The people have learned the movements of the tides and currents and the habits of the fish at Pu'uloa. They have worked hard to build stone fishtraps that take advantage of these tides and currents. A few weeks ago, they prepared for this full moon by repairing some of the walls of the fishtrap. Kapono and Keoni waded out with their fathers and replaced the fallen stones, building the walls so that they would be submerged in the high tide, and about nine inches above water at the lowest tide. The fishtrap has two long stone walls. One wall is built out from the shore and the other runs parallel to it before curving into a large pocket at the seaward end. On the northern end of the wall there are dark stones about 13 feet apart. These stones are known as the "men" that drive the fish back over the wall if they try to escape. Another large, erect stone on the east side of the pond wall represents Kū'ulakai, the god of fishing. On the west end of the wall is a flat stone representing his wife, Hina.

When Kapono, Keoni and Pua reached the fishtrap, some of their neighbors were gathering with their nets. The kahuna made his way to the small walled ko'a (fishing shrine) near the shore. He offered fish to Kū'ulakai and chanted to Hina to draw the fish into the trap from the sea.

Everyone watched, holding their breath as the tide went out. In the low water of the receding tide, they soon spotted the fish trying to return to the sea. Silver flashes of akule, 'ō'io, and weke fish glistened in the sun, thrashing about. They could not escape over the walls of the fishtrap. When the kahuna gave the signal the people moved in, scooping the fish up in their nets. The men sorted the fish, sharing the catch among the families. Kānekua'ana had blessed them with a plentiful catch. They placed the extra fish in large gourds and released them in the fishpond nearby. Along the shore, Pua and her friends gathered limu (seaweed) to have with the fish.

That night, the families gathered to feast on the fish and limu from the sea and the kalo and 'uala from the land. Kapono and Pua fell asleep beneath the full moon, dreaming of fish glistening in the rich waters of Pu'uloa while Kānekua'ana, the akua mo'o, guarded over them.

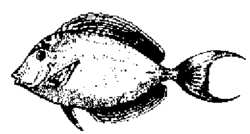
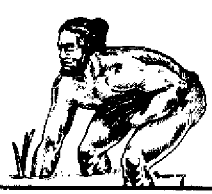


Fishtrap (pā) from Pu'uloa, O'ahu. The first fish caught was offered to Kū'ulakai, the god of fishing, represented by a Kū stone.

Student Activity Sheet

Name____________________________

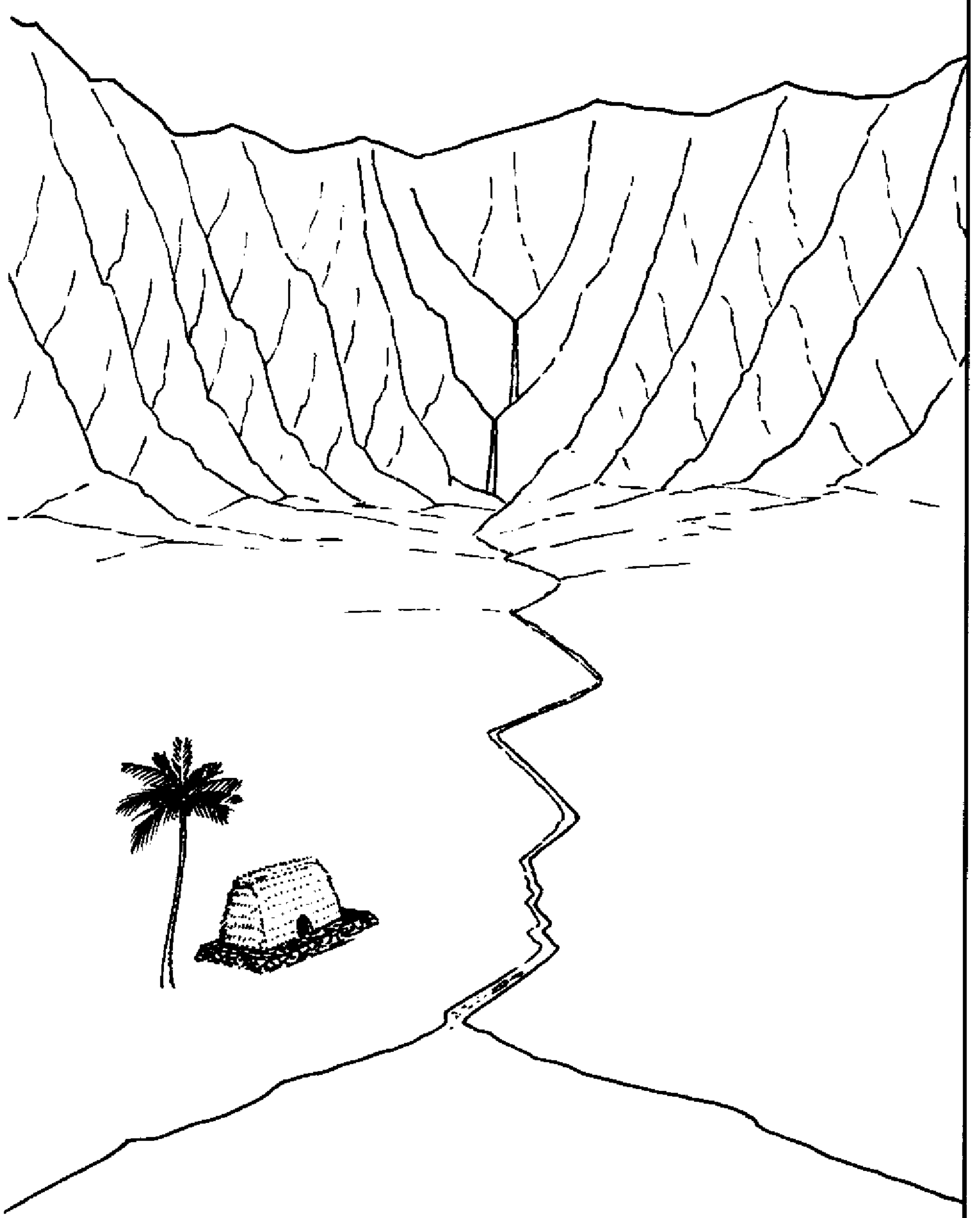
Complete this chart by listing the similarities and differences between the islands described in the stories.

	Majuro – Marshall Islands	**O'ahu – Hawaiian Islands**
type of island		
type of land division		
fishing 		
fishtraps 		
growing food 		
lifestyles 		

Student Activity Sheet
Ahupua'a

Name ______________________

Complete this geographic representation (or draw a new one on a separate sheet) of the ahupua'a where Pua and Kapono live. Draw each item listed in the "key" in the general area where it is found in the ahpua'a. Be sure to include your symbol for each item in the key.



KEY

stream

'uala (sweet potato)

reef flat

lo'i kalo (taro patches)

fishtrap

mai'a (bananas)

estuary

'ulu (breadfruit)

Student Activity Sheet
Wato

Name ____________________

Complete this geographic representation (or draw a new one on a separate sheet) of the wato where Giltmag lives. Draw each item listed in the "key" in the general area where it is found on the island. Be sure to include your symbol for each item in the key.

KEY

palm trees	lagoon	fishtrap	*Pandanus* trees
seaward reef flat	taro patches	coastal shrubs	breadfruit trees

From Fishtraps to Fishponds

- How are fishtraps different from fishponds? What factors might have led to the extensive development of fishponds from fishtraps in Hawai'i compared to other areas of the Pacific?

Hawai'i DOE Content Standards

Science: Using Unifying Concepts and Themes (MODEL)
- Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.

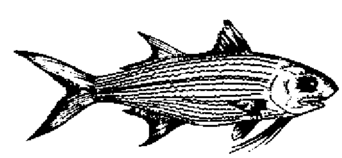
Social Studies: Places and Regions
- Students understand how distinct physical and human characteristics shape places and regions.

Grades 6 – 8 Performance Indicators

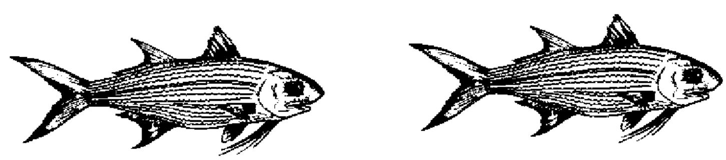
- Explain how models are used to understand things that are too small, too vast, or too potentially dangerous. Explain how models are used to understand processes that happen too slowly or too quickly.
- Demonstrate how more than one model can represent the same thing or process.
- Show evidence of the physical and human characteristics of world regions, countries or cities.
- Use data to compare the regions, countries or cities (culminating activity)

Key Concepts

- Fishtraps rely on the receding tide for trapping fish within stone enclosures. Fishponds are a true form of aquaculture where fish are grown and raised to maturity within enclosures.
- Fishtraps were common in the Pacific, but nowhere as extensively as in Hawai'i.
- The extensive development of fishponds in Hawai'i compared to other areas of the Pacific may have been due to several factors including the physical resources - protected bays and estuaries, extensive coastal reefs and streams; and human innovation and resources - large populations with highly organized social structure.



Activity at a Glance



Groups of students create and demonstrate fishtrap models. Students hypothesize what led to the extensive development of fishponds from fishtraps in Hawai'i compared to other areas of the Pacific.

Prerequisite

Pacific Patterns: Traditional Fishing and Land Use

Skills

reading comprehension, oral communication, reasoning, analysis, writing, model building

Assessment

Students:
- Create models of fishtraps and demonstrate how they work.
- Develop hypotheses to explain physical and human factors that might have led to the extensive development of fishponds in Hawaiʻi compared to other areas in the Pacific.

Time

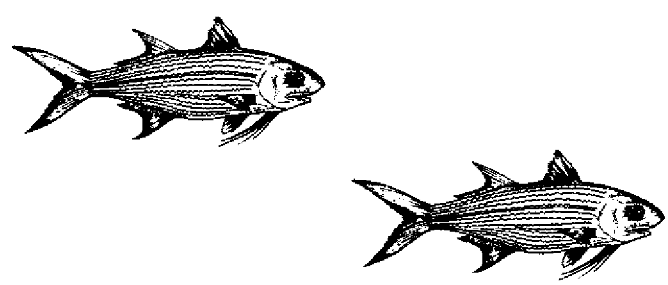
4 class periods

Vocabulary

loko iʻa – fishpond
loko kuapā – seawater fishpond on reef flat
mākāhā – sluice grate
aquaculture – raising of plants or animals in water
ʻauwai – ditch or small canal in fresh water
ʻauwai kai – ditch or small canal; sluice connecting the fishpond to ocean
umu – a heap of rocks used to catch small fish
pā – a primitive type fishtrap that has a single lane to guide fish at low or high tide, but not at both
loko ʻume iki – a shore fishtrap with lanes to guide fish at both low and high tide

Materials

Provided:
- student reading
- Project Kāhea Loko video



Needed:
- modeling clay
- bag of cinders
- dishpans (one for each of 5 or 6 groups)
- one jar of oregano (or similar tiny leaves)
- one-gallon containers (for storing and siphoning off water)
- meat basters (2 or 3 for groups to share)
- rulers
- reference materials (see suggestions at end of unit)

Advance Preparation

Duplicate the student reading and activity sheet (one copy for each student).

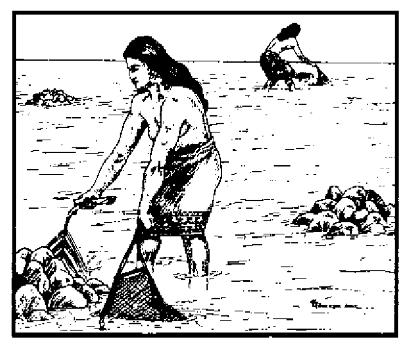
Optional: Gather some of the reference materials and check with the school librarian to see what other resources may be available to students.

Background

Fishtraps

Stone-walled fishtraps were constructed by islanders throughout Micronesia, Melanesia and Polynesia (Apple and Kikuchi, 1975). As described in the prerequisite activity, long V-shaped stone-walled fishtraps are common on the atolls of the Marshall Islands. Similar stone fishtraps can be found on Yap in the Caroline Islands as well as in the Gilbert Islands of Micronesia (Brower, 1981). And ancient Chamorros on Guam constructed a wedge-shaped stone fishtrap known as a gigao (Cunningham, 1992). In Polynesia, the Proto-Polynesian term "fota" refers to fishtraps that were built in Samoa, Futuna, Southern Cook Islands, Tahiti, Tuamotu and Mangareva (Kirch, 2001). Along the north shore of the ancient village of Maeva in Huahine (Society Islands) people still catch fish in the V-shaped stone fishtraps.

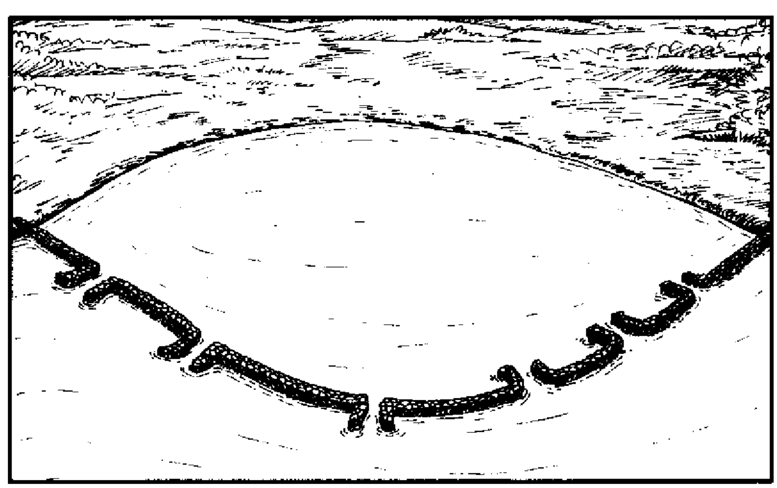
In Hawai'i, different types of fishtraps were built on reef flats. The stone-walled fishtrap described in the student reading in the prerequisite activity, the pā, is similar to fishtraps found throughout the Pacific. Pā are a primitive type fishtrap with a general V-shape, single lane to guide fish at low or high tide, but not at both. Fish were swept along with the current of outgoing tides and caught within the stone walls where they could be scooped out with nets. Akule, 'ō'io, weke, pualu, and makiawa [round herring] were all caught in this manner (Wyban, 1992).



umu

In addition, Hawaiians constructed fishtraps known as umu and loko 'ume iki. The umu (heap of rocks) was the simplest type of fishtrap. These small underwater "houses" were made of stones piled loosely into a mound with an opening on each end that allowed water to flow through. Women caught fish that hid inside these shelters by placing a woven net over one opening while shaking a palm frond or stick near the other opening. The fish inside the umu would swim away from the stick or palm and into the net.

The loko 'ume iki was a stone-walled fishtrap with multiple funnel-shaped lanes; some of which were wider toward the shore, others were wider toward the ocean. Fish were attracted to the currents created by the changing tides. When the tide went out, fish swam into the lanes. When the tide came in, fish swam out. Twice a day, when the tide changed, women placed nets across the openings to catch the fish as they swam in or out.



loko 'ume iki

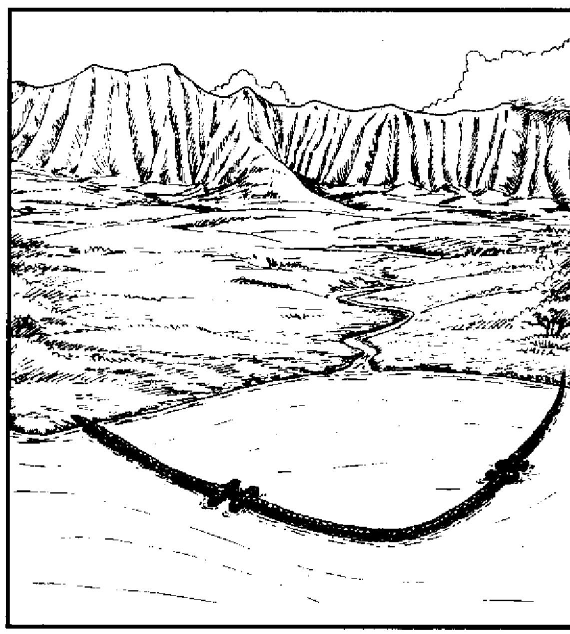
According to Kikuchi (1973), the loko ʻume iki had unusual ownership rights. Each fish lane had dual ownership. The fishing rights were assigned based on a lane or lanes on the ebb and flow of the tide. Certain people had the right to fish during the rise of the tide known as kai kī, and the others during the ebb, or kai emi. The entire fishtrap was the property of the ahupuaʻa, but the inward and outward fish lanes belonged to individuals of a family and thus were ʻohana (family) oriented. Legally, the ʻohana owned neither the land nor any fishpond, fishtrap, mountain weir, or fish shelter occurring in their domain, but rather they simply had the right as tenants to the use of specified food sources and to a share of the food obtained from these sources.

Fishtraps were constructed on the east end of Molokaʻi, at Puʻuloa (Pearl Harbor) on Oʻahu, at ʻAiʻōpio and Honokōhau on Hawaiʻi, and on Lānaʻi. As of 1975, all fishtraps in the Hawaiian Islands had fallen into various states of disrepair. The most intact fishtrap was at Palawai on Lānaʻi (Apple and Kikuchi, 1975).

Fishponds

While fishtraps were common in the Pacific, fishponds were constructed nowhere as extensively as in Hawaiʻi where large-scale development of aquaculture led to growing and storing fish in large stone-walled fishponds (Apple and Kikuchi, 1975). The extensive aquaculture practiced by Hawaiians made use of nearly every waterway from upland streams to lowland estuaries and bays. According to Apple and Kikuchi, "Hawaiian irrigation systems are among the largest and most well developed recorded anywhere in Polynesia except Futuna Island in western Polynesia."

The type of fishpond found only in Hawaiʻi, the loko kuapā, had massive stone seawalls that were up to several feet thick and rose above high tide level. These large ponds, which ranged from one to 523 acres, were built for the aliʻi (chiefs). When the aliʻi and their entourage traveled into an ahupuaʻa, fish were harvested from the ponds to feed the royalty. Based on Kikuchi's estimate (1973) of yield, Hawaiian fishponds probably produced more than two million pounds of fish per year.



loko kuapā

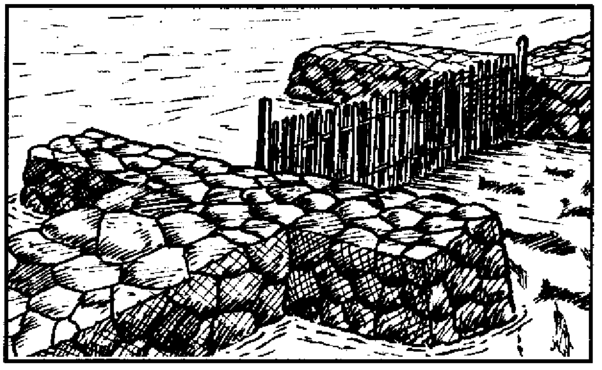
The question posed to students in this activity is, "What factors led to the extensive development of fishponds from fishtraps in Hawaiʻi compared to other areas of the Pacific?" There is no single answer to this question; many interrelated factors probably played a part. The physical setting of atolls with their lack of streams, and their low elevation, which exposes them to the storms and tsunamis (tidal waves caused by underwater earthquakes) in the south Pacific certainly played a part. The physical setting of the high Hawaiian Islands with protected bays and estuaries, extensive flat coastal reefs, and streams carrying nutrients and lava rocks was more conducive to the development of fishponds. While most of these conditions don't exist on atolls, they do exist on other high islands in the Pacific. So other factors must have played a role as well.

The human resources (the high number of people available in Hawai'i to pass the stones and build the walls) were undoubtedly a factor. It's estimated that it took thousands of men forming mile-long lines to pass the stones from the source to the site of a fishpond. The process of passing stones and constructing the walls of a loko kuapā could have taken up to a year.

On Kaua'i, 'Alekoko and Kalalalehua ponds were supposedly built from stone carried from Makali'i beach to the pond sites, a distance of between one and two miles. Another story places the source of stone as Makaweli, a distance of 15 miles. On Moloka'i, rocks were carried from Wailau Valley to Ka'ope'ahina pond in Kalua'aha, a distance of four miles (Kikuchi, 1973).

Kamakau (1976) estimates that the reconstruction of Kaneo'o and Kālepolepo ponds on Maui required approximately 10,000 men. Imagine the number of men needed in the original construction! Kikuchi (1973) adds that the massiveness of some of the shore type fishponds suggests that construction was intensive and lengthy, as well as costly in terms of material manpower, and subsidy in feeding and housing. The social organization of Hawaiian society that gave the ali'i power to mobilize large populations to build these royal ponds was a factor as well. And according to Hawaiian scholar Samuel Kamakau (1976) there must have been prolonged periods of peace for large numbers of people to cooperate on such huge projects.

Another factor is innovation. A distinguishing feature of Hawaiian fishponds is the mākāhā (sluice grate). The mākāhā were placed in the sluices or opening channels—the 'auwai kai near the sea, and 'auwai in the upland ponds. These immovable grates trapped mature fish in the pond and allowed water to circulate. They were constructed of branches of young lama or 'ōhi'a 'ai trees fastened together with cordage. The spaces between the branches were narrow enough to let young fish in and prevent mature fish from escaping.



mākāhā (sluice grate)

According to researchers Apple and Kikuchi (1975), the only other known sluice grate in the Pacific was found in the Gilbert Islands of Micronesia, and there it was a moveable panel in a fishtrap used like a swinging gate. These researchers also point to the mākāhā as the innovation that probably enabled Hawaiians to proceed from fishtraps to fishponds. Fishtraps rely on the receding tide for trapping fish within stone enclosures. Fishponds are a true form of aquaculture where fish are grown and raised to maturity within the enclosures. The original Hawaiian mākāhā may have been developed in upland lo'i kalo (taro terraces) where simple, smaller-scale sluice grates were used to control the water flow.

Some Hawaiian oral traditions associate the building of ponds with certain chiefs. By tracing the genealogy of the chiefs, the earliest dates of fishpond construction can roughly be estimated as early as the 13th century. There are also a number of references to Hawaiian fishponds constructed later in the 16 - 18th centuries (Wyban, 1992).

Teaching Suggestions

1. Review the readings from the prerequisite activity and discuss the features of the fishtraps in the Marshall Islands and in Hawai'i. (See also annotated references at the end of this unit that list sources of fishtrap illustrations.)

2. Divide the class into five or six groups and challenge students to create their own fishtrap models. Discuss the advantages of using models to learn more about how fishtraps function. (Models provide opportunities to explore, in a relatively short time and on a small scale, processes that take place over many hours and on a large scale, such as water circulation and tidal changes.)

3. Display the materials for groups to use in the creation of models and encourage students to select from these or other materials of their choice.

   Sample fishtrap model materials

   - dishpan – fill with water to be "ocean"
   - clay – make small balls to create "stone" walls (or use cinders)
   - bay leaves – use as the "fish"
   - gallon of water – add to the dishpan to raise the "tide"
   - meat baster – use to lower the water level by one inch, simulating low tide

4. Have groups mark their dishpans to show where the "shore" would be. Discuss design considerations.

   - What fishtrap shape would work with the outgoing "tide" to capture the most bay leaf "fish"?
   - How will you make sure fish come into your traps?
   - How will you keep the fish from escaping?
   - How will the depth of the water at high and low tide affect your design?

5. Ask groups to present their models to the class. Each group should demonstrate the fishtrap at high tide, add bay leaf "fish" and then use the meat baster to lower the tide. Have each student explain one aspect of the model, including:

   - the features of the fishtrap design;
   - how it compares to the fishtraps in the Marshall Islands;
   - how it compares to a Hawaiian fishtrap; and
   - why they chose their particular design.

   Discussion Questions

   - Which fishtrap models were most efficient for catching fish? Why?
   - Which elements of actual fishtraps were used most successfully?
   - How might some of the fishtrap models be re-designed to be more effective? (Try it!)
   - How could the fishtraps be modified to become fishponds used for growing fish?
   - How did the different types of models represent the same thing or process?

6. Show the Project Kāhea Loko video to introduce your students to Hawaiian fishponds.

7. Discuss the video and ask students if they know of any fishponds or fishtraps on your island. Distribute the student reading and ask students to review it and answer the study questions.

8. Challenge students to develop hypotheses about why there was such extensive development from fishtraps to fishponds in Hawai'i compared to other areas in the Pacific.

9. Collect students' answers and written hypotheses and discuss their ideas. See culminating activity on the Grades 6 – 8 Unit 1 Grid that challenges students to conduct research to support their hypotheses.

   Discussion Questions

   - What is the major difference between a fishtrap and the fishpond described in the reading?
     (Within stone walls of a fishtrap like the pā, fish are trapped with the outgoing tide. Fish are grown within the walls of a fishpond and are trapped by the mākāhā.)

   - What do you think were some of the physical features that led to the extensive development of fishponds in Hawai'i?
     (streams, large bays and estuaries; large quantity of stones)

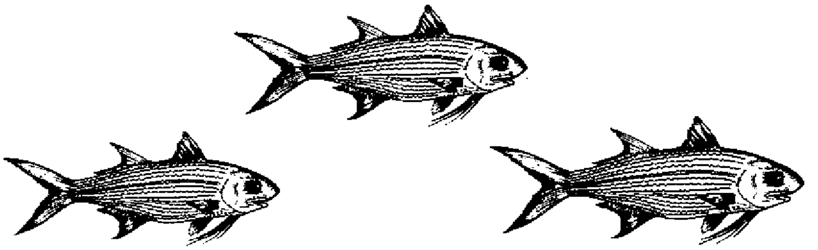
   - What might some of the social factors have been?
     (Large populations of commoners were available to do the work and they were organized and ruled by ali'i. Extensive periods of peace allowed time for construction.)

   - What technological innovation described in the story was most important to the evolution of fishponds? Why?
     (the mākāhā, since it allowed the water to circulate, but trapped the larger fish)

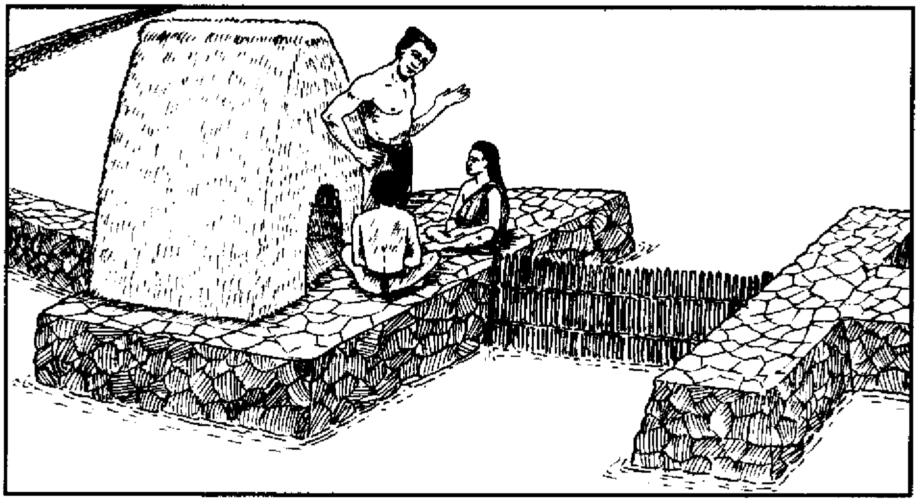
Adaptations/Extensions

- Have students design and construct fishpond models. See *Engineering Ingenuity* in Unit 3, Grades 4 - 5 of this guide.

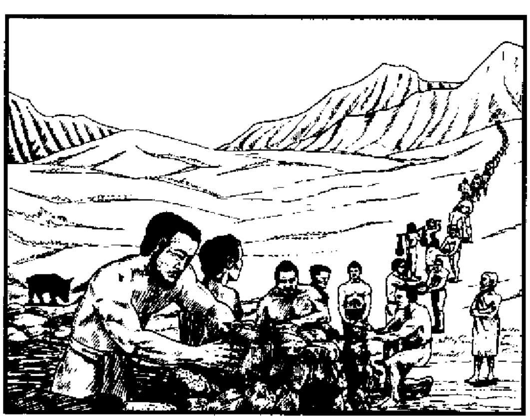
- Encourage students to research the extensive irrigation systems and aquaculture developed on Futuna Island in western Polynesia or the aquaculture practiced in the Gilbert Islands of Micronesia that were known to have developed sluice grates.



From Fishtraps to Fishponds — Student Reading

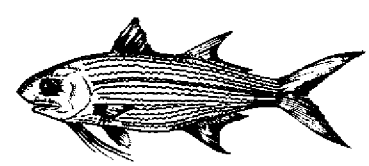


Pua and Kapono sit at the feet of their father, watching his eyes light up as he speaks. It is A.D. 1651 in Honouliuli—the largest ahupua'a (traditional land division) on the island of O'ahu. The land is blessed with freshwater streams that flow into a large estuary. This protected harbor is excellent habitat for many types of fish and shellfish. Their father is the kia'i loko (fishpond caretaker) of one of the royal fishponds. This loko kuapā (fishpond) belongs to the ali'i (chief) that rules over this part of the island. It was built by his command with the labor of thousands of maka'āinana (commoners). Laboring for nearly a year, they formed a mile-long line from the streambed to the fishpond site, passing the stones from one person to the next.



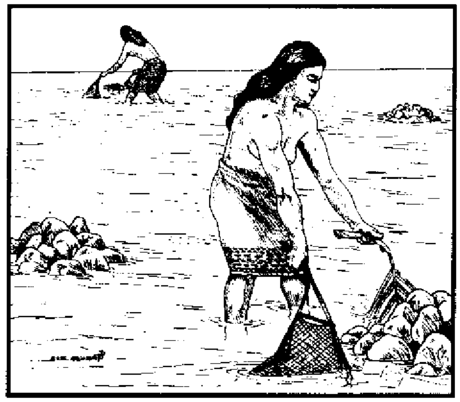
Today, the massive pond walls have two openings to the sea. These sluices are known as 'auwai kai. Each has an immovable grate (mākāhā) that controls the flow of water and traps the fish inside. Pua and Kapono are sitting near the mākāhā next to the hale kia'i (guardhouse) that shelters their father while he watches over the pond. Keeping a watchful eye on the walls, their father makes sure no maka'āinana come and attempt to take fish from the pond.

"Will there be moi (Pacific threadfin) for the ali'i too?" asks Pua. She knows the ali'i favor this tasty fish that no commoners are allowed to eat. " 'Ae, when the ali'i and all of his attendants come, there will be plenty of moi, 'ama'ama (striped mullet) and awa (milkfish) to feed them all. In the morning, Kapono, I want you to help me and your uncles with the large net to catch more fish in the pond."



moi (Pacific threadfin)

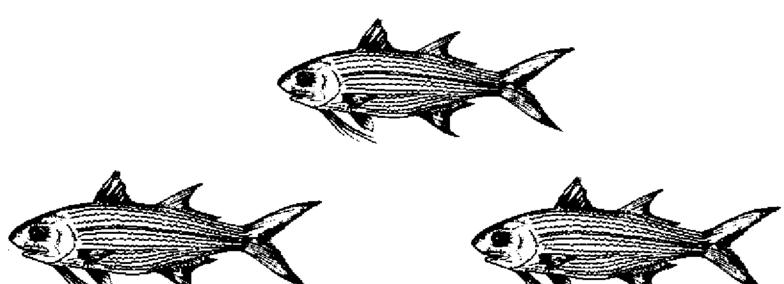
The next day, Pua and Kapono help to prepare for the visiting ali'i. Like their father, they both love to fish and each of them has become skilled in different ways. Pua has learned to weave baskets for trapping fish using the strong rootlets of the ʻieʻie plant. She is also skilled at catching fish in the simple fish trap—the umu she and her brother built on the reef flat. When she wades out to the umu, she hopes there will be a big fish hiding in the pile of stones. She approaches cautiously, carefully placing a scoop net over the opening on one end of the umu and waves a palm frond on the other end. The big uhu (parrotfish) inside is frightened and darts into her net.



Pua places the fish in her basket and joins her mother who is collecting limu (seaweed) and shellfish nearby. As they head to shore, they are drawn by the sounds of the men at the loko kuapā. Mother and daughter walk carefully on the sand, avoiding the nets that are drying there. These are prized possessions of the aliʻi and it is kapu (forbidden) for women and children to step over or near a net. It is believed that this will ensure that the power of the nets will not be lost. Married women, like Pua's mother, are also forbidden to walk on the walls of the loko kuapā. When Pua gets older and begins her monthly period, it will also be kapu for her to walk on the walls during that time.

Drawn to the excitement at the pond, mother and daughter watch the pai pai—men working together to drive fish into a big net. While some of the men hold the net, others are moving toward them, slapping the water with sticks. Kapono is slapping and shouting along with the others, frightening the fish into the net. The surface of the pond is churning with flashes of silver as the fish leap in the sunlight and become entangled.

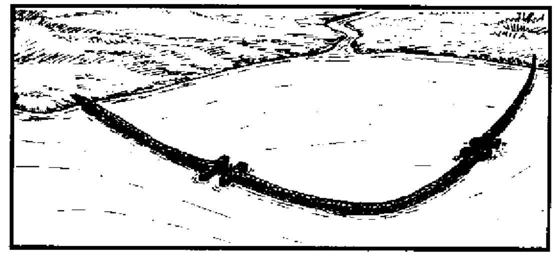
Pua and her mother make their way home for there is much work to be done. The fish they've caught need to be cleaned. The kalo that was harvested from the loʻi and then steamed, must be pounded to make poi. And lauhala mats need to be cleaned and ready for the lūʻau (feast). When the aliʻi and his attendants arrive, they will be fed well in Honouliuli.



Student Activity Sheet

Name ____________________

Fishtraps were common in the Pacific; fishponds were not. No other island groups had such intensive development of fishponds as the Hawaiian Islands. In the Pacific, the only known usage of a sluice grate other than in Hawai'i (where it is called mākāhā), is in a fishtrap in the Gilbert Islands of Micronesia. In that instance, the moveable sluice grate was used as "a panel which was closed a little before the ebb of the tide, trapping the fish" (Kikuchi, 1973). The loko kuapā described in this story is found only in Hawai'i.



The loko kuapā is unique to Hawai'i. By the end of the 18th century, there were more than 300 of these royal fishponds in the Hawaiian Islands.

1. Fishponds in Hawai'i probably evolved from the simpler fishtrap structures. How is the fishtrap described in the previous reading (see *Pacific Patterns* activity) different from the fishpond described in this story?

2. What physical features of the Hawaiian Islands might have led to the development of so many fishponds?

3. What human factors might have contributed to the development of fishponds from fishtraps in Hawai'i? Explain.

4. What technological feature described in the story was most important to the development of fishponds? Why?

Develop a hypothesis to explain why there was such extensive development from fishtraps to fishponds in the Hawaiian Islands compared to other areas of the Pacific.

My hypothesis: ____________________

Apple, Russell A. and William K. Kikuchi. 1975. *Ancient Hawaii Shore Zone Fishponds: An Evaluation of Survivors for Historical Preservation*. National Park Service, U.S. Dept. of the Interior.

Beckwith, Martha. 1970. *Hawaiian Mythology*. University of Hawai'i Press. Honolulu, HI.

Brower, Kenneth. 1981. *Micronesia: The Land, the People and the Sea*. Louisiana State University Press. Baton Rouge, LA and London. (See photograph of Micronesian stone fishtrap on Yap, p. 83.)

Cunningham, Lawrence J. 1992. *Ancient Chamorro Society*. The Bess Press. Honolulu, HI. (See pp. 35-36 for description and drawing of ancient fishtrap known as gigao.)

Hermes, Jules. 1994. *The Children of Micronesia*. Carolrhoda Books, Inc. Minneapolis, MN. (Includes color photographs of Micronesian children and describes cultural traditions.)

Kirch, Patrick Vinton and Roger C. Green. 2001. *Hawaiki, Ancestral Polynesia: An Essay in Historical Anthropology*. Cambridge University Press. Cambridge, England.

Stoddard, Tim. 2002. *Ho'ololi 'Āina: The Changing Landscape of Honouliuli*. The Nature Conservancy of Hawai'i. Honolulu, HI.

Wyban, Carol Araki 1992. *Tide and Current: Fishponds of Hawai'i*. University of Hawai'i Press. Honolulu, HI. (See Chapter 13 for drawings and descriptions of types of fishponds and fishtraps.)

Websites

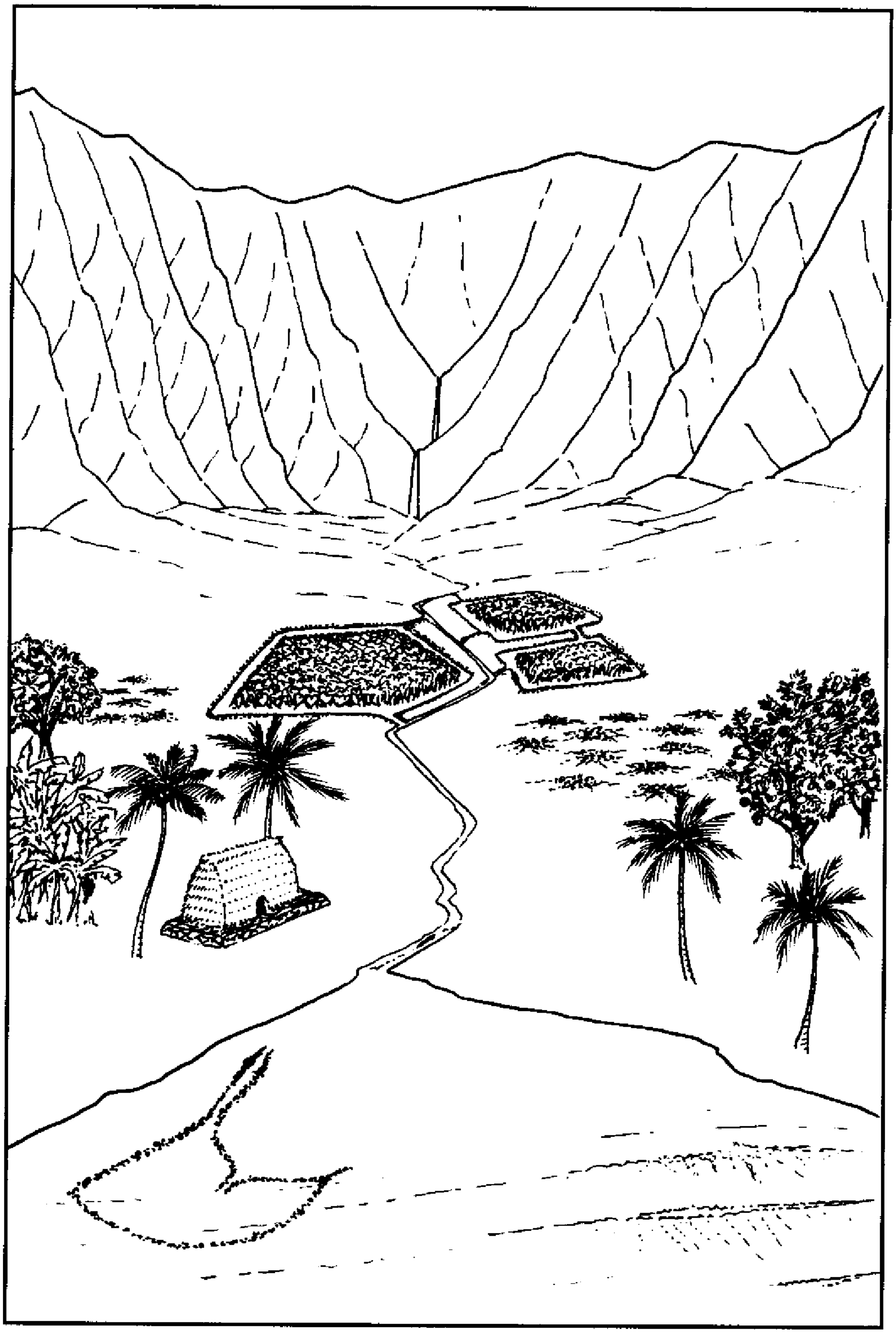
Lujan, Makahoa. *Na Loko I'a o Hawai'i Nei*. <mahakoa@niti.net> http://www.niti.net/~mahakoa/loko.html (Site features an ahupua'a diagram including different types of fishponds and links to other sites about fish and fishponds in Hawai'i.)

Northwestern Hawaiian Islands Multi-Agency Education Project. <nwhi-questions@hawaii.edu> http://hawaiianatolls.org. (Site has maps, photographs and satellite images of atolls and various features on the Islands.)

Spennemann, Dirk H.R.1998. *Essays on the Marshallese Past*. Second Ed., Albury, Australia. http://marshall.csu.edu.au/html/essays/es-arc-1.html (See Website for copies of the essays and aerial photographs of fishtraps on Majuro.)

United Nations Environment Programme (UNEP). 1998-2001. *Small Island Resource Management: Traditional Resource Use and Management*. <arthur.dahl@unep.ch> http://www.unep.ch/islands/sieme1.htm (Site has information on traditional resource use and management on small islands in the Pacific.)

University of California, Santa Barbara, National Center for Geographic Information and Analysis, Institute for Social Behavioral and Economic Research. 2001. *French Polynesia Research* (Copyright © 2001 Barbara Walker.) http://www.isber.ucsb.edu/~blewalker/french_poly_photo_gallery.htm (Researcher Barbara Walker includes a good photograph of a stone wall fishtrap in the Society Islands.)



The fertile soils and greater rainfall on high volcanic islands, like the Hawaiian Islands, sustain more agriculture than on atolls, but subsistence fishing was still a vital part of early Hawaiian life. Where conditions were suitable, Hawaiians constructed walled fishtraps to take advantage of currents and tides to trap fish.

Unit 1 at a Glance

Grades 9 - 12

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: Places and Regions Use physical and human characteristics of places and regions to evaluate how systems are structured, connected, and change over time.	**1E.** What physical conditions and human characteristics determined where loko iʻa (fishponds) and fishtraps were located on an island? **Activity: *He ʻĀina Momona***	• The variability of physical conditions in different regions of the Islands—location of perennial flowing streams, natural depressions in the land, extensive reef flats, sand bars, and protected bays—determined where Hawaiians could build different types of fishponds and fishtraps. • The social organization of Hawaiian society gave the aliʻi (chiefs) power to mobilize large populations to build fishponds, and prolonged periods of peace enabled people to laulima (cooperate) on such huge projects.	Students: • Draw an island map showing key physical features and designating where they would build different types of fishponds or fishtraps. • Write a summary describing: - the types of fishponds or fishtraps they would build in different regions of the island; - the physical characteristics of each region that would enable them to build the ponds or traps; and - the human characteristics that will help them to succeed.
Social Studies: Places and Regions	**1F.** How are early Hawaiian irrigation systems and fishponds in an ahupuaʻa reflections of Hawaiian ingenuity? How have the physical features in the ahupuaʻa been modified by human activities over time? **Activity: *Ka Hana Noʻeau a nā Kūpuna***	• Irrigation systems and fishponds in an ahupuaʻa are evidence of Hawaiians' engineering and organizational skills to make effective and efficient use of water to grow food and cultivate fish. • Human activities have modified the courses of streams and replaced many early irrigation systems and fishponds with modern development.	Students: • Complete drawings they create during a field trip and label the major natural features of an ahupuaʻa and the key features in a fishpond. • Write a summary describing how early Hawaiian irrigation systems and fishponds in an ahupuaʻa are a reflection of Hawaiian ingenuity, and how the physical features in the ahupuaʻa have been modified by human activities over time.

Culminating Activity

Students select a research topic to compare an aspect of the fishpond or ahupuaʻa they have studied with a fishpond or ahupuaʻa in another region. They make an oral presentation of their research using visual aids such as posters or diagrams. (Students could work independently or in the teams that were formed for the field excursion.)

Possible Research Topics: a) Compare early Hawaiian water uses within an ahupuaʻa to modern uses of stream water within a region of the island; b) Compare the fishpond studied in the field excursion to a fishpond in an ahupuaʻa with different physical conditions.

Students' written work and oral presentations should include: a) an explanation of the human and physical characteristics that are important to their topic; b) the human and physical changes to the fishpond or ahupua'a over time; and c) a summary that predicts human and/or physical changes to the fishpond or ahupua'a in the future.

Review criteria for assessing students' research and presentations and have them work with you to develop a rubric (see sample rubric below).

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	'Ano Mākaukau (Almost at Standard)	Mākaukau 'Ole (Below Standard)
Social Studies: Places and Regions Explain types and/or functions of regional systems based on multiple human and physical characteristics. ***Points*** ____	Writing and presentation clearly explains human and physical characteristics and offers new insights.	Writing and presentation clearly explains human and physical characteristics.	Writing and presentation addresses some human and physical characteristics, but prompting is needed.	Writing or presentation does not explain multiple human and physical characteristics.
Identify human and physical changes (boundaries, migration) within a regional system over time. ***Points*** ____	Content clearly identifies changes over time and shows skillful organization of ideas with logical sequence of thoughts.	Content is organized and clearly identifies changes over time.	Content is valid, but lacks organization so that changes over time are difficult to understand.	Content is lacking in information or accurate information.
Use the information gathered to evaluate (predict, conclude judge or summarize) the human and/or physical effects on regions. ***Points*** ____	Predictions make logical use of information gathered and show innovative well-developed ideas.	Predictions make logical use of information gathered and show critical thinking.	Predictions build on information gathered but cover only human or physical effects.	Predictions don't connect logically to information gathered.
Visual Aids **Points** ____	Visual aids enhance understanding of content; and have high visual appeal.	Visual aids support content and are appropriate quality.	Visual aids are minimal and not entirely effective.	Visual aids are incomplete or not appropriate.

I NOTICED:

6

He ʻĀina Momona
A Land Sweet and Fertile

- What physical conditions and human characteristics determined where loko iʻa (fishponds) and fishtraps were located on an island?

Hawaiʻi DOE Content Standard

Social Studies: Places and Regions
- Students understand how distinct physical and human characteristics shape places and regions.

Grades 9 - 12 Performance Indicators

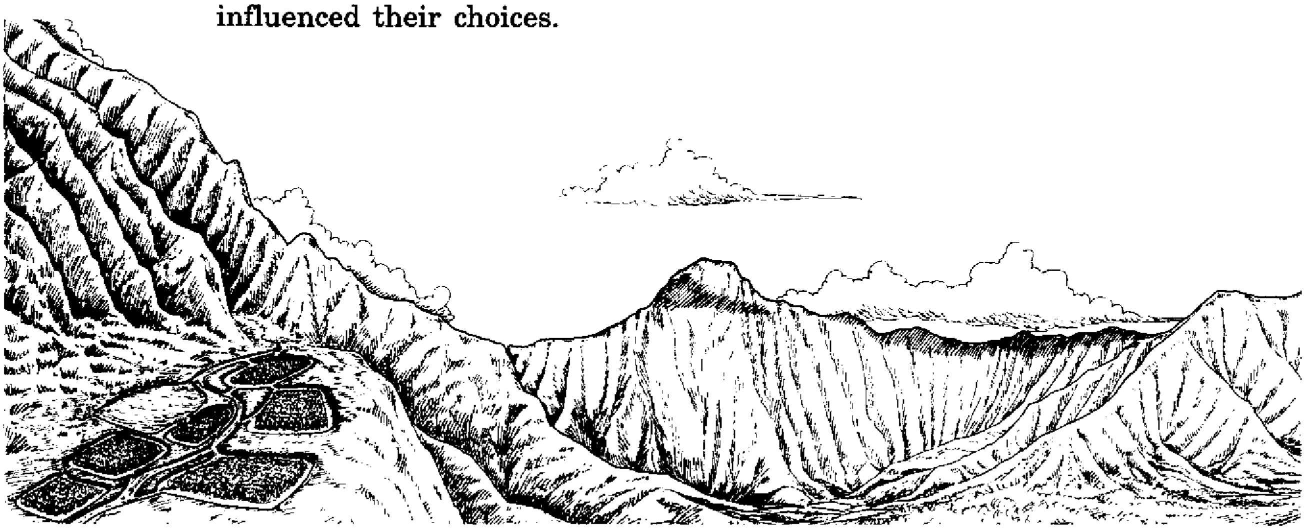
- Explain types and/or functions of regional systems based on multiple human and physical characteristics.
- Explain the interrelationship(s) within parts of regional systems.

Key Concepts

- The variability of physical conditions in different regions of the Islands—location of perennial flowing streams, natural depressions in the land, extensive reef flats, sand bars, and protected bays—determined where Hawaiians could build different types of fishponds and fishtraps.
- The social organization of Hawaiian society gave the aliʻi (chiefs) power to mobilize large populations to build fishponds, and prolonged periods of peace enabled people to laulima (cooperate) on such huge projects.

Activity at a Glance

Students create a map showing the main physical features of one of the Hawaiian Islands. They select a time period in early Hawaiʻi and decide where they would build fishponds and fishtraps on the island and identify the physical and human characteristics that influenced their choices.



Skills

mapping, analysis, problem solving, writing

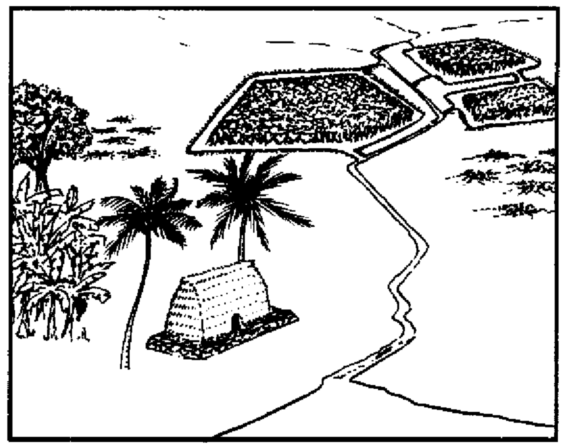
Assessment

Students:
- Draw an island map showing key physical features and designating where they would build different types of fishponds or fishtraps.
- Write a summary describing:
  - the types of fishponds or fishtraps they would build in different regions of the island;
  - the physical characteristics of each region that would enable them to build the ponds or traps; and
  - the human characteristics that will help them to succeed.

Time

2 – 3 class periods

Vocabulary



loko iʻa – fishpond
kuapā – seawall
mākāhā – sluice grate
survey – to look over and examine carefully
kuhikuhipuʻuone – an architect or priest who advised concerning the building and locating of fishponds, temples, or homes
perennial stream – stream that flows year-round

Materials

Provided:
- student activity sheet
- student reading
- fishpond and fishtrap illustrations (See *Loko Iʻa* lesson, Unit 1, Gr. 4 - 5.)
- Kāhea Loko videotape

Needed:
- color pencils
- island maps

Advance Preparation

Copy the student reading and the activity sheet for each student. Make copies or transparencies of the fishpond and fishtrap illustrations in the *Loko Iʻa* lesson. Gather different types of maps of your island, including relief maps that depict physical features such as streams and mountains or contour maps that show elevation with contour lines (see Resources at the end of this lesson).

Background

Physical conditions and rainfall vary considerably from windward to leeward sides of the Hawaiian Islands. Most rainfall is the result of northeast trade winds carrying moisture to the windward sides of the Islands. The highest rainfall occurs just to the leeward side of the summits on islands that are lower than 6,000 feet in elevation. The highest rainfall on higher islands occurs on the windward slopes between 1,500 and 6,000 feet elevation. The location of perennial flowing streams determined where Hawaiians could build their extensive irrigation systems for loʻi kalo (taro terraces). And the presence of streams and groundwater springs was critical to the location of fishponds. Natural depressions in the land, extensive reef flats, sand bars, and protected bays also determined where Hawaiians could build different types of fishponds and fishtraps.

The human resources—the high number of people available in Hawaiʻi to pass the stones and build the walls was an important factor in the construction of fishponds. It's estimated that it took thousands of men forming mile-long lines to pass the stones from the source to the site of a fishpond. The process of passing stones and constructing the walls of a loko kuapā could have taken up to a year. The social organization of Hawaiian society gave the aliʻi (chiefs) power to mobilize large populations to build these royal ponds. And according to Hawaiian scholar Samuel Kamakau (1976), there must have been prolonged periods of peace for large numbers of people to cooperate on such huge projects.

Teaching Suggestions

1. Write "loko iʻa" and "he ʻāina momona" on the board and ask students what they think these mean. Explain that "loko" is pond and "iʻa" is fish and that "he ʻāina momona" is a fat land or a land sweet and fertile--a land with many fishponds. Ask students which areas on their island they would refer to as "he ʻāina momona."

2. Distribute the student reading and discuss the importance of the loko iʻa, the amount of time and effort it took to build a loko kuapā, and the different types of fishponds and fishtraps that Hawaiians built.

3. Show the Kāhea Loko video. Discuss the video using the full-page illustrations of the fishponds and fishtraps (provided in the *Loko Iʻa* lesson).

   Discussion Questions

   - What features do most Hawaiian fishponds have in common?
     (They have mākāhā [sluice grates], ʻauwai or ʻauwai kai [channels], and they are fed by streams or springs.)
   - Which fishponds and fishtraps were located near the sea?
     (loko kuapā, loko puʻuone, loko ʻume iki, umu and sometimes loko wai)
   - Which were located inland?
     (loko wai and loko iʻa kalo)
   - How do you think fishponds are different from fishtraps?
     (Fishtraps rely on the receding tide for trapping fish within stone enclosures. Fishponds are a true form of aquaculture where fish are grown and raised to maturity within enclosures.)

4. Divide the class into groups and give each group some sample maps to review. Ask students to locate the main physical features such as streams, mountains, and bays or estuaries on the maps and conduct a discussion.

   Discussion Questions

   - How do maps show physical features on the island?
   - Which type of map is most useful for locating physical features? Why?
   - How is elevation shown?
   - What are the major differences between windward and leeward sides of the island?

5. Distribute the student activity sheet and review the instructions for students to create their own maps. Give students time to work on the activity and complete it as homework.

6. Have students complete the writing assessment activity to summarize their maps and the human and physical characteristics that would enable them to build fishponds or fishtraps in the sites they select on their maps.

7. Have students compare their maps to maps that show where fishponds are located on the island. See http://mano.icsd.hawaiigov/~ckomoek/. This site by the Hawaiʻi Office of Historic Preservation includes maps with traditional ahupuaʻa and fishponds.

Adaptation/Extension

- Have students complete a second map that shows how their island could change after a few hundred years. Have them estimate the island population and indicate what types of fishponds they would build.

Resources

Kamakau, Samuel Mānaiakalani. 1976. *The Works of the People of Old (Nā Hana a ka Poʻe Kahiko).* Bishop Museum Press, Honolulu, HI.

Sources of Island Maps

Ahupuaʻa Action Alliance. <lcruz@hawaii.edu> http://www.ahupuaa.net/gislinx.html. (This site provides links to sites with maps and mapping tools.)

Hawaiʻi Stream Research Center (HSRC).1996. *Perennial Streams.* (University of Hawaiʻi Center for Conservation Research and Training, the State Department of Land and Natural Resources Aquatic Resources Division, and the National Tropical Botanical Garden Limahuli Gardens) mkido@hawaii.edu http://www2.hawaii.edu/hsrc/home/welcome.htm (This site provides color maps that show where streams are located on each island.)

Historic Preservation Office. *Experimental Database Server.* Hawaiʻi Department of Land and Natural Resources. <Clifford_G_Inn@exec.state.hi.us> http://mano.icsd.hawaii.gov/~ckomoek/ (This site, which is still being developed, provides maps by island that include traditional ahupuaʻa and fishponds.)

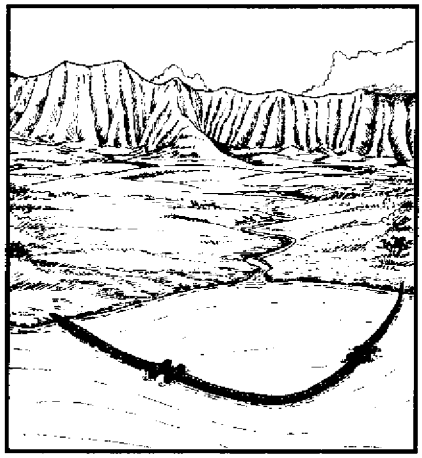
Juvik, Sonia P. and James O. Juvik. Editors. 1973. *Atlas of Hawaiʻi.* Third Edition, 1998. Department of Geography, University of Hawaiʻi at Hilo, University of Hawaiʻi Press, Honolulu, HI.

Kailua Bay Advisory Council. http://www.kbac-hi.org (Has excellent maps of the Kailua Bay area.)

Student Reading

"He ʻāina momona nō ia."

(It is a land sweet and fat.)
This was said of an area with many fishponds.



loko kuapā

Hawaiians built different types of fishponds to take advantage of the landform or terrain of the ʻāina (land) and the resources available, such as water and rocks. The loko kuapā is the type of fishpond that most people think of when referring to loko iʻa (fishpond). It is a seawater fishpond with rock walls built on a reef flat. This type of fishpond was built only in the Hawaiian Islands. These fishponds were prized areas that were kept securely by the chiefs and the mōʻī (king).

The Loko Iʻa

Constructing a loko iʻa was no easy feat. First, a kuhikuhipuʻuone (architect) would select the construction area. He and his team of kahuna (experts) would determine the type and size of the pond and choose a site with conditions (such as protected areas, large flat coastal reefs or the flow of streams) that would allow the pond to work efficiently and effectively. If the pond was to be a loko kuapā, a large supply of rocks for the construction of the walls had to be available. And most importantly, thousands of men (and women) were needed to build the kuapā (walls) on the seaside. It's estimated that it took thousands of men forming mile-long lines to pass the stones from the source to the site of a fishpond. The process of passing stones and constructing the walls of a loko kuapā could have taken up to a year. The social organization of Hawaiian society gave the aliʻi (chiefs) power to mobilize large populations to build these royal ponds. And according to Hawaiian scholar Samuel Kamakau (1976), there must have been prolonged periods of peace for large numbers of people to cooperate on such huge projects

In the legend of Kūʻulakai, the god of fishing, Kūʻula's fishpond at Lehoʻula, Hāna, Maui, was said to be 20 feet thick and 10 feet high. The loko kuapā in the Islands were from one to 523 acres in size. These kuapā were not only masterfully built, they are also great works of art. Fishponds added to the environment both aesthetically and economically.

After the kuapā was finished, the mākāhā (sluice grates) had to be made. The mākāhā were constructed of wood from lama or ʻōhiʻa ʻai trees. They were placed in openings (ʻauwai kai) in the pond wall, which allowed water to circulate and fish to be trapped. The narrow slits in the wooden grate allowed young fish to enter the pond, and then trapped them inside the pond when the fish grew larger than one half inch thick. Fish could be harvested from the pond as they gathered at the mākāhā during changes in the tide.

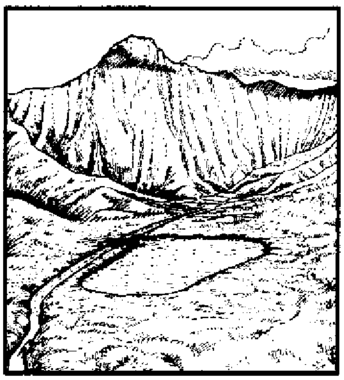
mākāhā (sluice grate)

loko puʻuone

Hawaiians also stocked their fishponds with pua iʻa (juvenile fish). The type of fish depended on the type of fishpond. Loko wai, loko puʻuone and loko kuapā were usually stocked with fish such as ʻoʻopu (goby), ʻamaʻama (striped mullet), or awa (milkfish). A kiaʻi loko (pond keeper) was selected by the aliʻi (chief) to maintain, repair and protect the loko iʻa. It was a big responsibility and the kiaʻi loko received a lot of respect from the villagers.

Different Types of Loko Iʻa

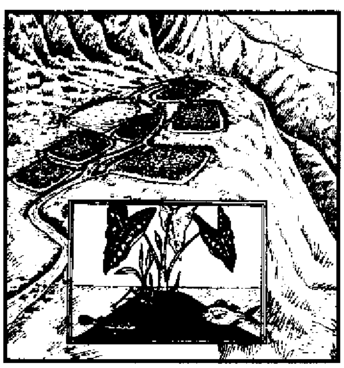
In addition to the loko kuapā, Hawaiians built three other types of fishponds. The loko puʻuone was built along the shore where there was a puʻuone (a sand dune or heap of sand) to hold the water in the pond. Fresh water flowed into these ponds from streams or groundwater springs and fish were attracted to the brackish water that resulted from the mix of salt and fresh water.



loko wai

Inland they built loko wai by digging out natural pools and constructing ʻauwai (ditches) to connect the pond to a stream. Another type of fishpond was the loko iʻa kalo (taro fishpond) that was used to raise fish and kalo. In these freshwater ponds, kalo was planted in mounds of soil that provided habitat for the fish.

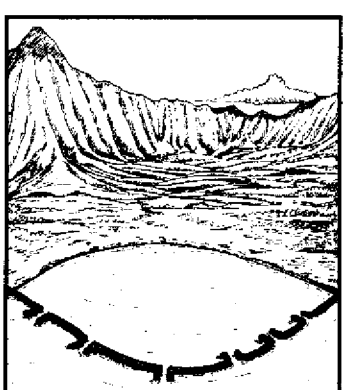
Hawaiians also built different types of fishtraps along the coast. These were simpler structures that did not have a mākāhā. The simplest form was the umu—a heap of rocks that provided shelter for fish. Hawaiians made these traps by piling stones loosely into a mound. Fish were attracted to the limu (seaweed) that grew on the surface of the stones. Women caught fish by placing a net over the opening on one side while shaking a palm frond or stick along the other opening.



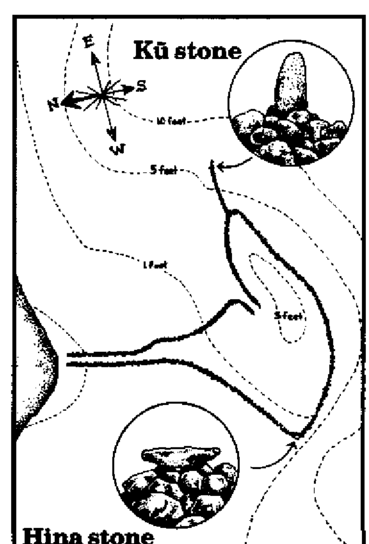
loko iʻa kalo

A much larger fishtrap, the loko ʻume iki, was built on the reef flat. The walls of this fishtrap had many funnel-shaped openings or lanes. Some of the lanes were wider toward the shore, and others were wider toward the ocean. Twice a day, women came to gather fish that were attracted to the currents in the lanes produced by the changing tide.

Another type of fishtrap was a V-shaped structure known as a pā (a wall, fence, or enclosure). This primitive type of fishtrap had a single lane to guide fish at low or high tide, but not at both.



loko ʻume iki



pā (V-shaped fishtrap)

Student Activity Sheet

Name:____________________________

Date:________________

Select a time period in the past between A.D. 400 and 1830, when the last fishpond was built in Hawaiʻi. Imagine that you are a Hawaiian aliʻi (chief) living in that period. As the leader, you must decide what needs to be done to ensure survival and future sustenance for your people. You wish to create agricultural plots, fishponds and fishtraps on your island. You must decide which places on your island have the physical features needed to support loʻi kalo (taro patches) and different types of fishponds and fishtraps. You also need to delegate various tasks among the people, according to their expertise. Think about the human resources available—what the population of your island would be for the time period selected. Decide which values and human characteristics will be important for you to succeed. Think about the tools that are available to you for constructing loʻi, fishponds and fishtraps.

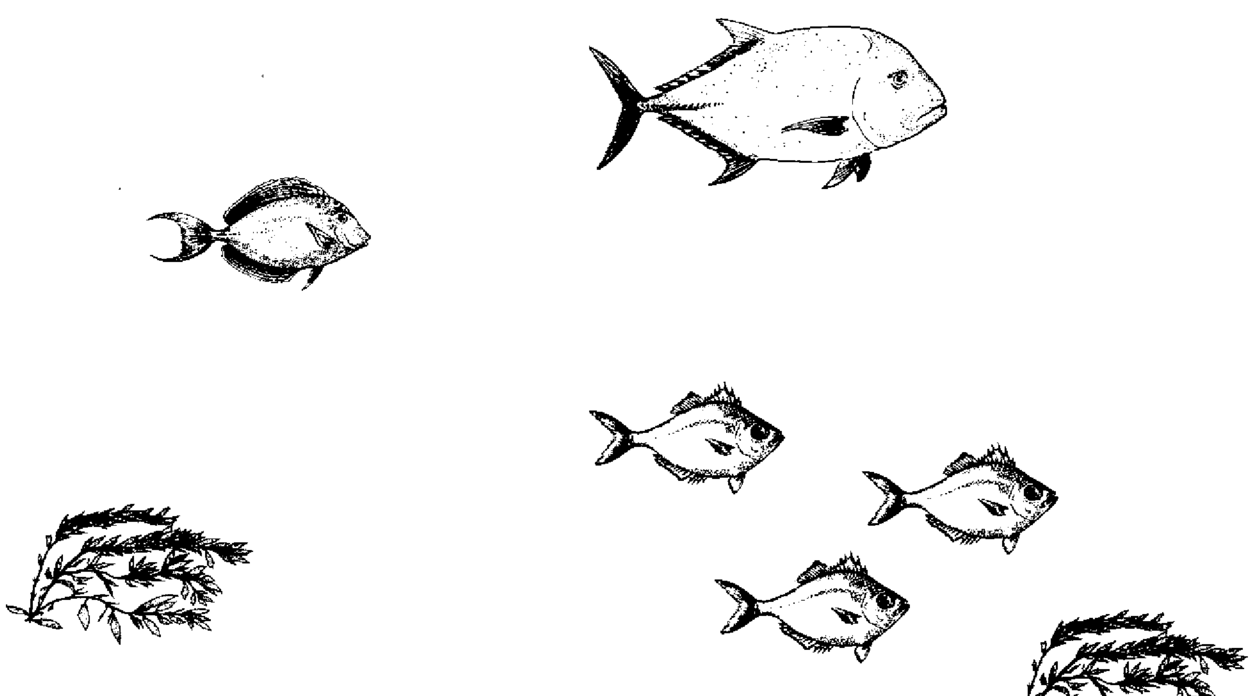
Estimates of the Total Hawaiian Population in Different Time Periods*

A.D.	
400	20-30
1000	3,000
1650	200,000
1778	300,000
1849	80,641
1872	56,897
1876	45,000
1891	34,436

- Create a map of your island. Include the following features and label them on your map:
  - major streams, bays, and estuaries
  - inland ponds or lakes
  - major sand dunes
  - mountains
  - reef flats
- Determine where you will build loʻi kalo and at least two different types of fishponds or fishtraps. Use colored pencils to outline the areas that will be loʻi and fishponds or fishtraps. Label each feature with the type of pond and a name of your choice.
- Include directions (windward, leeward) and mark the highest elevations.
- Write a summary describing:
  - types of fishponds or fishtraps that you would build in different regions of the island;
  - the physical characteristics of each region that you selected for your sites and why they were important; and
  - the human characteristics that will help you and all of the ʻohana to succeed.

*Sources: Hall III, W. Thos. 1997. *The History of Kailua*. Self-published. Kailua, HI.

Vann, Michael G. 1997. *Contesting Cultures and Defying Dependency:Migration, Nationalism, and Identity in Late 19th Century Hawaii.* The Stanford Humanities Review 5.2: 146-173.



Ka Hana No'eau a nā Kūpuna
The Wise Deeds of our Ancestors

Huaka'i (Field Trip) 1

- How are the early Hawaiian irrigation systems and fishponds in an ahupua'a reflections of Hawaiian ingenuity?
- How have the physical features in the ahupua'a been modified by human activities over time?

Hawai'i DOE Content Standard

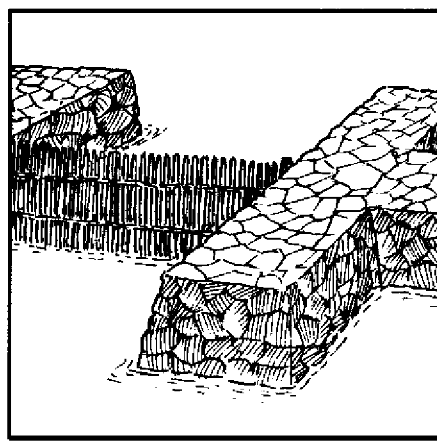
Social Studies: Places and Regions
- Students understand how distinct physical and human characteristics shape places and regions.

Grades 9 - 12 Performance Indicators

- Explain types and/or functions of regional systems based on multiple human and physical characteristics.
- Explain the interrelationship(s) within parts of regional systems.
- Identify human and physical changes (boundaries, migration) within a regional system over time.
- Use the information gathered to evaluate (predict, conclude judge or summarize) the human and/or physical effects on regions. (culminating activity)

Key Concepts

- Irrigation systems and fishponds in an ahupua'a are evidence of Hawaiians' engineering and organizational skills to make effective and efficient use of water to grow food and cultivate fish.
- Human activities have modified the courses of streams and replaced many early irrigation systems and fishponds with modern development.

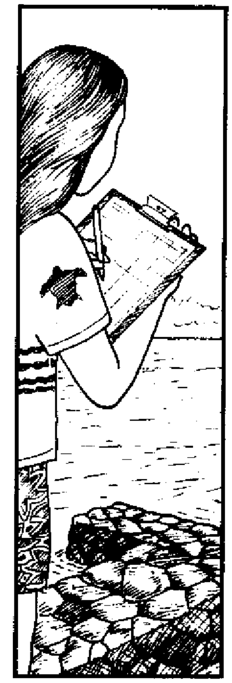


Prerequisite

He 'Āina Momona

Activity at a Glance

Students visit a fishpond and conduct an informal survey of the site to discover the interrelationships between parts of the ahupua'a system and the ingenuity involved in the construction of Hawaiian fishponds.



Skills

analytical/deductive reasoning, problem solving, drawing, writing

Assessment

Students:

- Complete drawings they create during a field trip and label the major natural features of an ahupuaʻa and the key features in a fishpond.
- Write a summary describing how early Hawaiian irrigation systems and fishponds in an ahupuaʻa are a reflection of Hawaiian ingenuity, and how the physical features in the ahupuaʻa have been modified by human activities over time.

Time

1 day field trip (at least 3 hours at the site)

Vocabulary

huakaʻi – field trip; excursion
ahupuaʻa – traditional Hawaiian land unit usually extending from mountain summits to the outer edges of reefs
loko iʻa – fishpond
kuapā – walls of a fishpond
mākahā – sluice grate
ʻauwai kai – ditch or small canal connecting the fishpond to the ocean
survey – to look over and examine carefully
environment – all the conditions, circumstances, and influences affecting an area
biodegradable – material that will decompose into the environment
non-biodegradable – material that will not decompose into the environment
moku – land district
ili – land division, next in importance to an ahupuaʻa
hukilau – a seine; to fish with a seine

Materials

Provided:

- student activity/data sheets

Needed:

- 8.5" x 11" graph or grid paper (optional for drawing fishpond)
- 8.5" x 11" drawing paper
- 10 feet of rope
- plastic portfolios (optional)
- clipboard
- pencils or pens
- rubber bands (to place over papers on clipboards)

Advance Preparation

Make arrangements to visit a fishpond. (See field sites in the Appendices for more information.) Contact the fishpond manager to set dates for a visitation. Allow time for travel and at least three hours at the site. Proper protocol should be discussed and information on the area should be shared prior to the visitation. Students should also be instructed on proper procedures in collecting samples and recording data as well as appropriate attire for working with water and soil. Make sure students have clipboards and if desired, plastic portfolios to protect their work.

Copy the data sheets (one set of sheets for each student). Note that some loko i'a are further restored or better maintained than others, so surveying and measuring and mapping activities should be tailored to the particular site. Some adjustments to the instructions on the activity sheets may be necessary if, for example, all features of the loko i'a are not measureable or accessible to the students. Note: this activity was designed for one class of 25 - 30 students. See Adaptations at the end of this lesson for taking more than one class to the loko i'a.

Background

The social organization of Hawaiian society was reflected in the land divisions and the social structure of the ruling ali'i. "In old Hawai'i, kings awarded custody of lands to their loyal supporters. Island kingdoms (mokupuni) were divided into districts (moku) which were further parceled into minor chiefdoms (ahupua'a). Because boundaries with neighboring ahupua'a were not crossed with impunity, these land divisions typically extended from the high forested mountains to offshore fishing grounds, providing the residents with access to the resources of all elevations without crossing borders. Within each ahupua'a were 'ili, smaller holdings, each typically worked by one extended family" (Kane, 2001). Each ahupua'a was ruled by a konohiki who was responsible for the distribution of water and land.

Within ahupua'a that had the essential natural resources, Hawaiians demonstrated exceptional organizational and engineering skills in their construction of irrigation systems and fishponds. The engineering involved constructing multiple stone lo'i (terraces) for growing kalo (taro) and extensive 'auwai (ditches) to transport water from the streams into the many terraces. The flow of water was diverted from the stream into the lo'i, then back into the stream, and finally down to the fishpond, where the combination of fresh and salt water attracted fish.

As the human population increased, the land within an ahupua'a was put into more intensive cultivation and the organization of the society became more complex as well. By the 15th century, moku (land districts) comprised of multiple ahupua'a were formed. Each moku had fixed boundaries and was overseen by an ali'i 'ai moku who answered to the ali'i nui that ruled the island.

These moku and some 'ili are still recognized today as land districts in the Islands. The extensive network of 'auwai, the stone terraces and fishpond walls, however, are mostly deteriorated. Those features that remain are silent testimony to the engineering ingenuity of the Hawaiians who constructed them.

Teaching Suggestions

1. Highlight and summarize the prerequisite activity, *He 'Āina Momona.*

   Discussion Questions

   - What did you learn from the activity?
   - Describe one type of loko i'a you placed on your map. Why did you select it for that location?

- What were your limitations in building different types of fishponds?
  (availability of streams, protected bays, reef flats, estuaries and sufficient number of people to conduct the work)
- What were the most important human characteristics? Why?
  (ability to laulima [cooperate] and organize; leadership ability; engineering skills to build ponds and terraces that work)
- If you were to complete a map when your population had grown much larger, how might your map be different?
  (There would be more fishponds and lo'i, and there would be land divisions such as moku and ahupua'a to organize people and resources.)

2. Read the following quote and discuss it with your class.

   "From a very early time in their history, Hawaiians, to a greater extent than any other Polynesians, exhibited engineering and building skill, ingenuity, industry, and planning and organizing ability in three types of construction: the grading and building of terraces for growing wet taro; construction of irrigation ditches and aqueducts to bring water to these terraces; and construction of fresh- and salt-water fishponds."

   \- E.S. Craighill Handy, Elizabeth Green Handy and Mary Kawena Pukui, 1972

   Discussion Questions
   - What skills were involved in the three types of construction?
   - How did Hawaiians make efficient use of fresh water within an ahupua'a?

3. Discuss protocol for visiting the pond. If students would like to compose an oli (chant) or mele (song) to share with the fishpond coordinator encourage them to do so. For suggestions on composing simple mele, see *Haku Mele Aloha*, Unit 3, Grades 4 - 5.

4. Divide the class into four teams. You may give Hawaiian names to the teams or have the students name them. Explain that the class will be visiting a fishpond and that the teams will rotate at regular intervals (30 – 45 minutes) to different stations set up at the pond. The four stations and the tasks for each one are:

   a. Physical Environment Station – Take measurements of the loko i'a and water flow rate, if the pond has an opening.
   b. Human Factors Station – Note the human influences on the fishpond and its environment.
   c. Fishpond Mapping Station – Draw the loko i'a and label the important features.
   d. Ahupua'a Mapping Station – Sketch the ahupua'a where the fishpond is located to gain a wider perspective on the interrelationships between different parts of the ahupua'a.

5. Review the instructions on the student activity/data sheets to help students focus on their responsibilities during the field trip. Have the class practice measuring and mapping an area at school. If a Walking Wheel is available, practice using it or have students determine how many normal paces equal 10 feet. Measure a 10-foot rope and have students pace the rope and count their paces. Also calculate how many inches are in one normal pace. (See the FAST module on "Initial Survey" listed in the Resources at the end of this lesson.)

Investigations at the Pond

- Every student should be actively working with team members to sketch and record information at each station. This information will be useful when sharing with other teams.
- After activities are completed, time could be given for large group activities or, if time allows, give students additional time to write a reflection about what they learned and the significance of the loko i'a.

After Visiting the Fishpond

5. Ask teams to share what they learned at each station and hold a class discussion.

   Discussion Questions

   - What is the function of the mākāhā? What does the meaning of mākāhā (mākā = type of stone and hā = breath) reveal about the Hawaiian perspective?
   - What physical features of the pond are the most significant?
   - What physical features in the ahupua'a enabled Hawaiians to build a fishpond in that location?
   - What changes do you think were made to the existing fishpond over time? What is the evidence of change?
     (Pond walls may have been cemented, which cuts down on pond circulation, or fresh water streams may have been diverted away from the pond. Runoff of soil from upslope may have changed the water quality.)
   - How have the physical features in the ahupua'a been modified by human activities over time?
     (Streams may have been diverted for use in other areas, or channeled to prevent flooding. Coastal areas may have been developed for recreation, housing or hotels.)

6. Ask students to complete the drawing and writing assessment activities that address the focus questions of this lesson. See the culminating activity for regional comparisons.

Adaptations/Extensions

- If two or three classes (about 90 students) are participating in the huaka'i, plan some large group activities, such as throwing net, participating in hukilau, or loko i'a clean up. Work with the field site coordinator to plan activities.
- Arrange for students to use gill nets at the fishpond to see how the nets are used and to demonstate laulima; working together to catch the most fish with the least amount of effort. An additional benefit of this exercise is that the bottom of the pond becomes stirred-up and, if the tide is outgoing, the silt can be flushed from the pond.
- Have students write mini-research papers about the ahupua'a they have studied. They could look for maps that show changes over time or research Hawaiian legends that mention certain significant or unusual land formations such as 'Alekoko on Kaua'i, and Keahiakahoe on O'ahu). Alternatively, they could create a short story that explains a landform in the ahupua'a.

- Ask students to read case studies on fishponds to construct the history from the pre-contact era until today. A table could be created comparing older maps and surveys with those of today. Moliʻi, Heʻeia, Nuʻupia and Waikalua fishponds on Oʻahu, ʻUalapuʻe fishpond on Molokaʻi, Kaloko fishpond on Hawaiʻi, ʻAlekoko fishpond on Kauaʻi and Koʻieʻie fishpond on Maui are fishponds that could be studied. See Resources listed for each island in Unit 3, *Huli Kanaka* activity.

year	similarities	differences	changes
1800s 1900s present			

Resources

Beckwith, Martha. 1970. *Hawaiian Mythology.* University of Hawaiʻi Press. Honolulu, HI.

Fajardo, Tisha. *Hawaiian Fishponds.* (Pahoa High School) http://www.pahoahs.k12.hi.us/cat/examples/fishponds.html

Fishpond ʻOhana Restoration - Maui (for Maui). 2001. *Koʻieʻie Loko Iʻa, Historical Royal Fishpond of South Maui.* (Copyright © 2001 - Cathi Ltd) <info@ForMaui.org> http://www.formaui.org/3wave2-1.

Green, Linda Wedel. 1993. *A Cultural History of Three Traditional Hawaiian Sites on the West Coast of Hawaiʻi Island. Kaloko-Honokohau.* (Copyright © United States Department of the Interior National Park Service, Denver Service Center) http://www.cr.nps.gov/history/online_books/kona/history.htm

Handy E.S. Craighill, Elizabeth Green Handy and Mary Kawena Pukui. 1972 (1995). *Native Planters in Old Hawaii: Their Life, Lore, and Environment.* Bernice P. Bishop Museum Bulletin 233, Bishop Museum Press. Honolulu, HI.

Henry, Lehman L. (Bud). 1993. *He'eia Fishpond: Loko I'a O He'eia.* Ke'alohi Press. Honolulu, HI.

Kamakau, Samuel M. 1976. *The Works of the People of Old (Nā Hana a ka Poʻe Kahiko).* Bishop Museum Press. Honolulu, HI.

Kane, Herb Kawainui. 2001. *Ancient Hawaiʻi.* An e-Book Publication. (Hawaiian Paradise Trading Company, Ltd., and Herb Kawainui Kane) <service@hitrade.com> http://hawaiiantrading.com/herb-kane/ah-book/index.html

Newman, T. Snell. 1973. *Man in the Prehistoric Hawaiian Ecosystem. In*: E. Alison Kay, (ed.), *A Natural History of the Hawaiian Islands: Selected Readings.* University of Hawaiʻi Press. Honolulu, HI.

Pottenger III, Francis M. and Donald B. Young. 1992. *The Local Environment: Fast 1, Foundational Approaches in Science Teaching.* Second Edition. University of Hawaiʻi Press. Honolulu, HI.

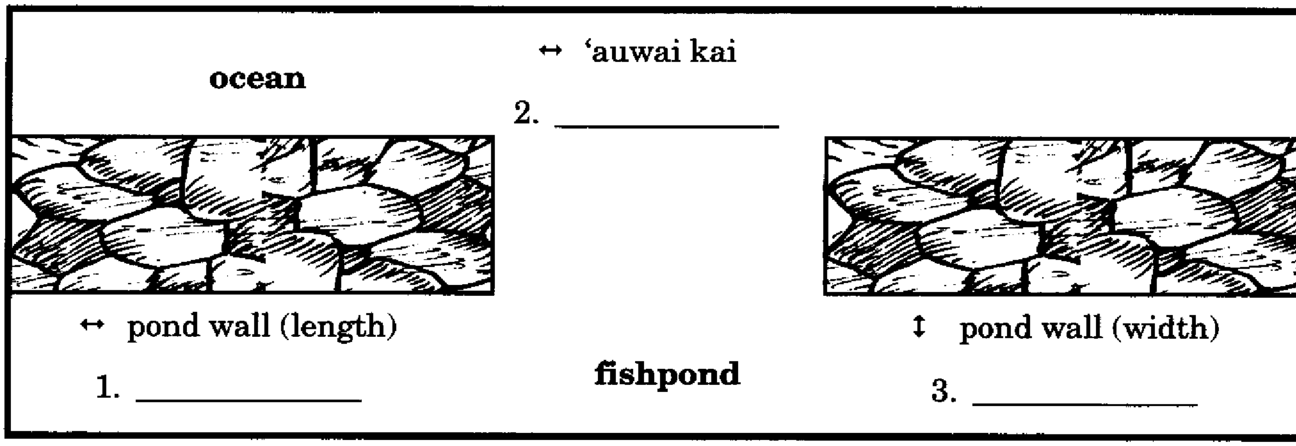
Titcomb, Margaret. 1972. *Native Use of Fish in Hawaiʻi.* University of Hawaiʻi Press. Honolulu, HI.

Student Data Sheet — Physical Environment Station

Name ______________________ Date ________ Time ________

Type of pond: ______________________ Tide Notes ______________________

Does this pond have mākāhā? ______________________



A. Use the Walking Wheel and measure:
   1: Length of wall
   2: Width of ʻauwai kai
   3: Width of wall

Record your measurements on the numbered lines above.

B. Draw an arrow in the diagram above to indicate the direction the tide is flowing through the ʻauwai kai.

C. Measure:
- the speed that a float travels from one end of the ʻauwai kai to the other:

  __________ft. per second

- the water depth in the ʻauwai kai:

  __________ft.

D. Calculate the flow rate:

Depth (ft.) x Width of ʻauwai kai (ft.) x Flow (ft. per sec.) x 60/7.5 = GPM (gal. per min.)

__________ x __________ x __________ x 60/7.5 = __________

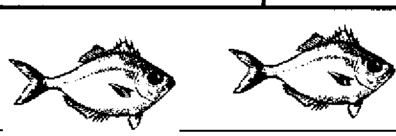
E. What is the function of the mākāhā and the ʻauwai kai?

Student Activity Sheet   Human Factors Station: Scavenger Hunt

Team Name ______________________________ Date____________

INSTRUCTIONS: Work with your team to find evidence of things that may have changed the fishpond (directly or indirectly) and its environment. Find items listed in the left column and describe them and their effect or connection to the loko iʻa.

Find	Describe (what it is and its relationship to the loko iʻa)
a landform that is included in Hawaiian moʻolelo (legend)	
evidence of people caring for this environment	
a negative human impact on this environment	
a human-made object that is biodegradable and one that is non-biodegradable	
evidence of a significant human change to this environment	
something human-made that is beautiful	
evidence of Hawaiian ingenuity	



Completed by: ______________________

Student Activity Sheet — Loko Iʻa Mapping Station

Team Name ______________________________ Date__________

Name of Ahupuaʻa ______________________________

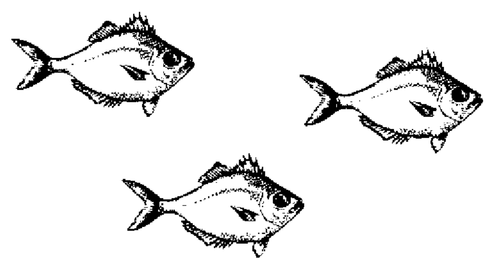
Name of Moku ______________________________

INSTRUCTIONS:

1. Find an area at the loko iʻa where you have a good view and perspective of the fishpond.
2. On the reverse side of this sheet draw a detailed diagram of the loko iʻa
3. Label the mākāhā, ʻauwai kai, and the kuapā.
4. Include directions on your drawing (showing mauka and makai) and show where any streams flow into or close to the pond.

REFLECTIONS:

Describe how the fishpond functions.



How is the fishpond a reflection of Hawaiian ingenuity or skill?

How do you think the fishpond has changed over time?

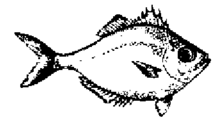
Your name here: ______________________________

Student Activity Sheet — Ahupua'a Mapping Station

Team Name ______________________________ Date__________

Name of Ahupua'a ______________________________

Name of Moku ______________________________



INSTRUCTIONS:

1. Find an area at the loko i'a where you have a good view and perspective of the ahupua'a – from mauka to makai.
2. On the reverse side of this sheet sketch the ahupua'a showing significant natural features such as streams, peaks, ridges, and coastline.
3. Add the fishpond to your sketch and other features of Hawaiian culture that are visible, such as heiau or lo'i kalo (taro terraces)

QUESTIONS:

What is the relationship between the stream and the fishpond?

What physical characteristics of this ahupua'a make this a good site for a fishpond? Explain your answer.

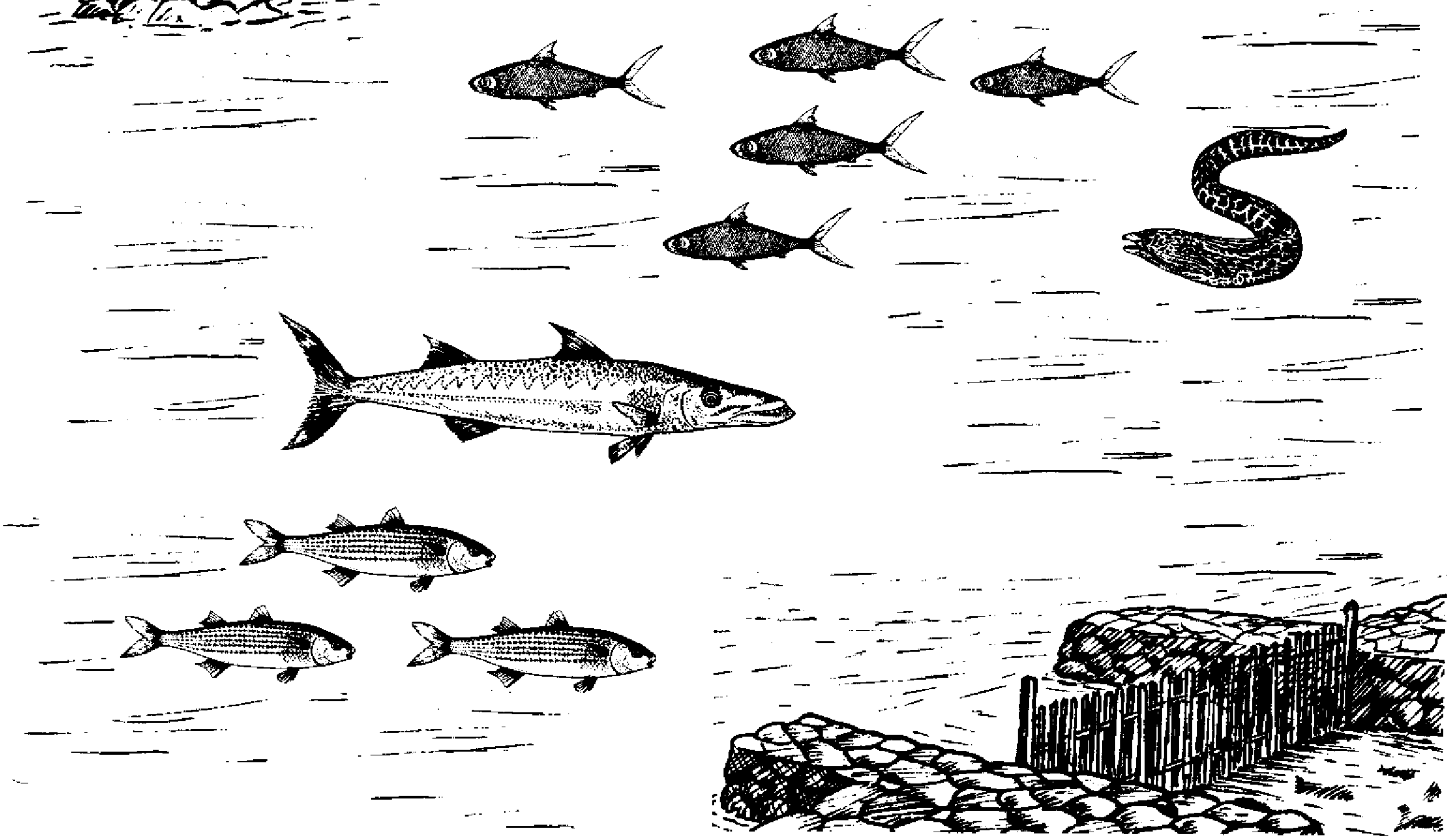
What do you think are the most significant changes that people have made to this ahupua'a over time?

Your name here: ______________________________

UNIT 2
Life in a Fishpond

"Loko kuapā
Flowing, growing
Parrot fish, goby, eel
Important to all Hawaiians
Fishpond."

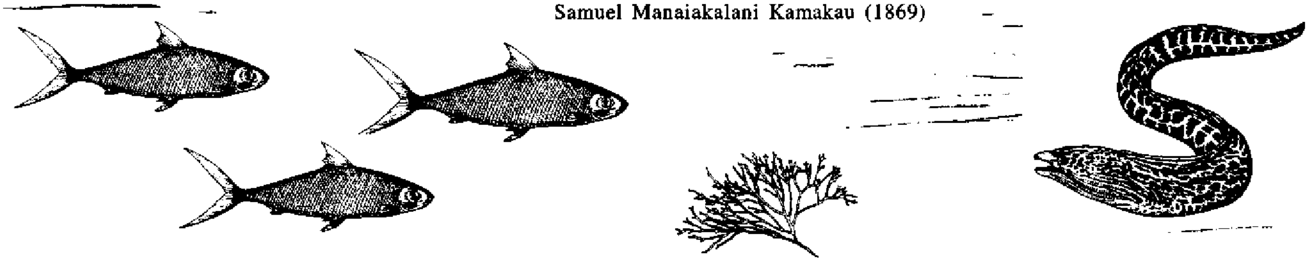
Fraser Ann-Fellez, Grade 5
Maunawili School, O'ahu



Life in a Fishpond

"I have seen them become like wild things at a sluice where fish had been treated like pet pigs, they would crowd to the mākāhā where the keeper felt them with their hands and took whatever of them they wanted."

Samuel Manaiakalani Kamakau (1869)



The most important source of energy that influences life on Earth comes from the sun, which the Hawaiians called lā. It determines night from day and affects the climate, which in turn determines the kinds of organisms that can live in certain regions. The second most important sky energy is mahina (moon). Modern science has revealed that day length (the hours of light), water temperature and the phases of the moon are the primary environmental cues that control when cold-blooded animals, such as fishes and invertebrates, reproduce.

All early civilizations made observations and had some knowledge of the movements of the sun, moon, planets and stars. The ancient Hawaiians made practical use of this knowledge in their daily lives. Not only did this knowledge help them in navigating the oceans, they were also able to determine the best times to plant crops and gather fish. Early Hawaiians knew that changes in the seasons correlated with changes in day length (Fig. 1). By observation and trial and error, early Hawaiians also found that the distribution and abundance of various plants and animals in the ahupuaʻa, and especially in the ocean, would change with the seasons.

Special assistants (kilo lani) to the aliʻi were able to predict the changes in season by knowing when and where the sun would rise and set upon the horizon. By tracking the different phases of the moon, they could predict the rise and fall of the ocean tides. At the time of the full moon and the new moon, the tides are at their highest and lowest levels. During the summer months, the tides rise to higher and drop to lower levels than during any other time of the year.

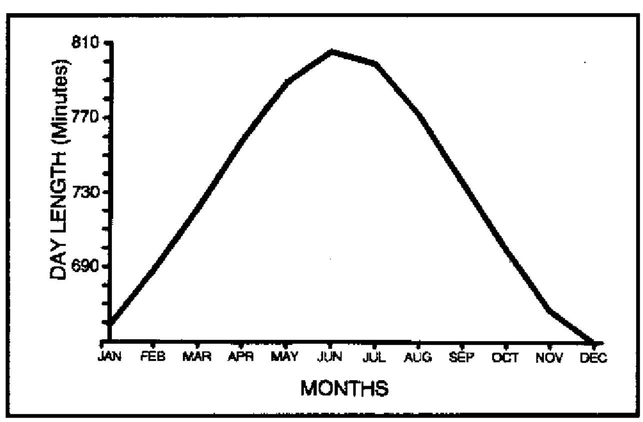
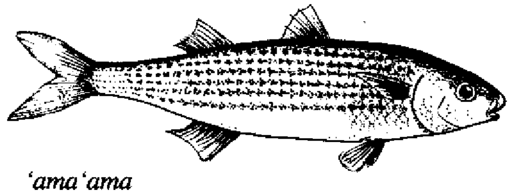


Figure 1. Temporal changes in day length in Hawaiʻi. (Data summarized from Dillingham Hawaiian Tide Calendar)

The Hawaiians also could predict when and where to find an abundance of certain species of fish. They knew which fish are naturally attracted to certain currents and which fish would gather at the mouths of rivers and streams or to places of underground freshwater springs. This knowledge of fish behavior and tidal fluctuations aided the kuhikuhipuʻuone (architect of fishponds) in determining where to build certain fishponds and fishtraps.



'ama'ama

Hawaiians knew that during ho'oilo (the wet season) when the seas are stormy, large schools of 'ama'ama (mullet) would gather when they were fat with eggs in places such as Kāne'ohe Bay and Pearl Harbor. Legend has it that the millions of droplets from the surf pounding on the shore would turn into mullet eggs since it was known that this is the time [December] when the 'ama'ama spawned in the sea.

Hawaiian Kapu

The ali'i (chief) would place a kapu (taboo) on certain fish, like the 'ama'ama, during their time of spawning so that there would always be young fish to replace the fish that were taken for food. In early Hawai'i, when a hau tree branch or a white kapa was placed along a shoreline, that area was kapu for fishing. Violation of a kapu was punishable by death. The 'ama'ama was kapu from November – March. Even the kia'i loko (fishpond guardians) were not allowed to violate this kapu to take young fry for stocking a fishpond. Another fishing kapu was enforced at the beginning of Makahiki—a four-months-long harvest festival, dedicated to Lono, a Hawaiian god of rain and agriculture. At this time, aku (bonito or skipjack tuna) were kapu, but 'ōpelu (mackerel scad) were allowed. At the end of the Makahiki, the kapu was lifted on aku, and enforced for 'ōpelu.

Fishing Regulations

Current fishing regulations include restrictions on the number and size of the fish that can be kept as well as the time of the year during which it is kapu. Restrictions have also been placed on the mesh size of the fishing nets used to catch certain species. For more information on fishing regulations and periodic updates, see the Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources Website at www.hawaii.gov/dlnr/dar. Click on Hawai'i Fishing Regulations.

Interdependence

Within the fishpond, all organisms are interdependent and each plays a role in the ecosystem. Microscopic plants—the phytoplankton—form the basis of the food chain, converting the sun's energy into sugars in the process of photosynthesis. Tiny zooplankton feed on the phytoplankton as do the awa (milkfish) who feed on the phytoplankton and the pond scum (filamentous algae and diatoms). The 'o'opu (gobies) are the bottom feeders that eat limu (algae) and insect larvae off the rocks.

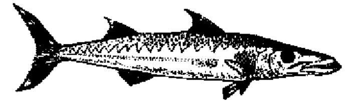
"Crabs are the scavengers scuttling along the pond's floor. Eels live in the cracks and crevices of the fishpond walls, and shrimp live in the grasses that line the shores. Pua 'ama (mullet fingerlings) feed on floating algae while the larger mullet ('ama'ama or 'anae) eat the detritus [decaying material] of the pond bottom" (Wyban, 1992).

This unit introduces students to the plants and animals that live in a fishpond. Activities help students explore interdependence among species, how lōkahi (balance) is maintained in the pond, and how marine organisms respond to seasonal and tidal changes.

References

Wyban, Carol Araki. 1992. *Tide and Current: Fishponds of Hawai'i.* University of Hawai'i Press. Honolulu, HI.

Unit 2 at a Glance



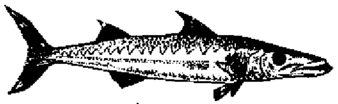
Grades 4 - 5

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: Cycle of Matter and Energy Flow Students trace the cycling of matter and the flow of energy through systems of living things.	**2A.** What plants and animals live in a fishpond and how are they dependent on one another? **Activity: *Recipe for a Fishpond***	• A fishpond ecosystem is composed of both living (plants and animals) and nonliving components such as water, soil, air, and minerals. • Energy from the sun flows through the ecosystem from the plants through the animals that consume them. • Nutrients are recycled within the ecosystem by the decomposers that break down dead and decaying organisms.	Students: • Diagram a fishpond food chain with labels for the producers, herbivores, carnivores and decomposers. • Write a description of the food chain that explains how "energy" is needed for all organisms to stay alive and grow, and identifies organisms that are reproducing, growing, dying and decaying.
Science: Organisms and Development – Interdependence Students describe, analyze, and give examples of how organisms are dependent on one another and their environments.	**2B.** How are plants and animals in a fishpond dependent on one another? How is lōkahi (balance) maintained in a fishpond? **Activity: *Lōkahi Game***	• Energy flows through a fishpond and nutrients are recycled by means of a complex series of food chains that make up a food web. • All parts of the food web are interconnected. A change in the environment may affect the lōkahi (balance) of the fishpond.	Students write an explanation of how lōkahi (balance) is maintained in the fishpond. Their explanations include: • how organisms depend on nutrients made available from the pond's decomposers; and • how plants and animals depend on each other in the exchange of nutrients.

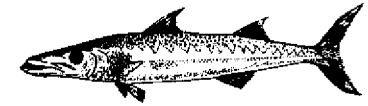
Culminating Activity

Students illustrate a fishpond food web that includes at least two food chains with labels for the producers (plants), the herbivores, omnivores, carnivores, and decomposers. Students select one of the following scenarios and illustrate how the fishpond food web would change: 1) A new housing development near the fishpond causes massive soil erosion into the pond, blocking sunlight to the pond bottom; or 2) The pond's ulua fish population is eliminated due to over-fishing. ***Students' drawings should be accompanied by a written description that explains at least two ways that the lōkahi (balance) of the pond was affected by the change.***

Teachers' Note: In the first scenario, increased siltation makes the water murky, blocking the sunlight that limu and plankton need for photosynthesis. Some of these plants die off, providing less food for herbivores, like the ʻamaʻama, so their populations decrease. The decline of these herbivores also affects the carnivores like the ulua and kākū that feed on them. In the second scenario, the ulua is a top-level carnivore in the pond. When the ulua is eliminated, the population of herbivores could increase. This increased population will cause these fish to compete for the phytoplankton and limu in the pond.



Sample Rubric for Unit 2 Culminating Activity



Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	'Ano Mākaukau (Almost at Standard)	Mākaukau 'Ole (Below Standard)
Science: Cycle of Matter and Energy Flow Show and describe how animals' food can be traced back to plants. ***Points*** _____	Food web drawing has more than two food chains and accurately shows how the animals' food is traced back to plants.	Food web drawing has at least two food chains and accurately shows how the animals' food is traced back to plants.	Food web drawing shows only one food chain; needs more information to show how animals' food is traced back to plants.	Drawing does not show complete food chains or show how animals' food is traced back to plants.
Science: Organisms and Development - Interdependence Identify how plants and animals depend on each other in the exchange of nutrients. (Gr. 5) ***Points*** _____	Writing accurately describes the flow of nutrients from one organism to another in the food web. Writing gives multiple examples of how plants and animals depend on each other in the exchange of nutrients.	Writing accurately describes the flow of nutrients from one organism to another in the food web.	Writing has some information to describe the flow of nutrients in the food web, but it is not complete.	Writing does not have enough information; does not describe the flow of nutrients in the food web.
Give examples of organisms responding to a changing environment. (Gr. 4) Explain how changes in a specific niche affect the population of organisms living there. (Gr. 5) ***Points*** _____	Writing accurately describes at least two ways the scenario would affect the other organisms in the fishpond. Content shows excellent critical thinking and ability to develop ideas.	Writing accurately describes at least two ways the scenario would affect the other organisms in the fishpond. Content goes beyond facts and details to develop ideas; shows critical thinking.	Writing shows only one way that the fishpond would be affected by the change described in the scenario. Content is good, but needs more examples and more evidence of critical thinking.	Writing does not have enough information; and/ or accurate information; shows no critical thinking.

I NOTICED:

Recipe for a Fishpond

- What plants and animals live in a fishpond and how are they dependent on one another?

Hawaiʻi DOE Content Standard

Science: Cycle of Matter and Energy Flow

- Students trace the cycling of matter and the flow of energy through systems of living things.

Grades 4 - 5 Performance Indicators

<u>Grade 4</u>

- Show how animals' food can be traced back to plants.
- Describe how "energy" is needed for all organisms to stay alive and grow.
- Give examples where organisms are reproducing, growing, dying, and decaying.

<u>Grade 5</u>

- Describe how animals' food can be traced back to plants.
- Explain how "energy" is needed for all organisms to stay alive and grow.
- Give examples where organisms are reproducing, growing, dying, and decaying.

Key Concepts

- A fishpond ecosystem is composed of both living (plants and animals) and nonliving components such as water, soil, air, and minerals.
- Energy from the sun flows through the ecosystem from the plants through the animals that consume them.
- Nutrients are recycled within the ecosystem by the decomposers that break down dead and decaying organisms.

Activity at a Glance

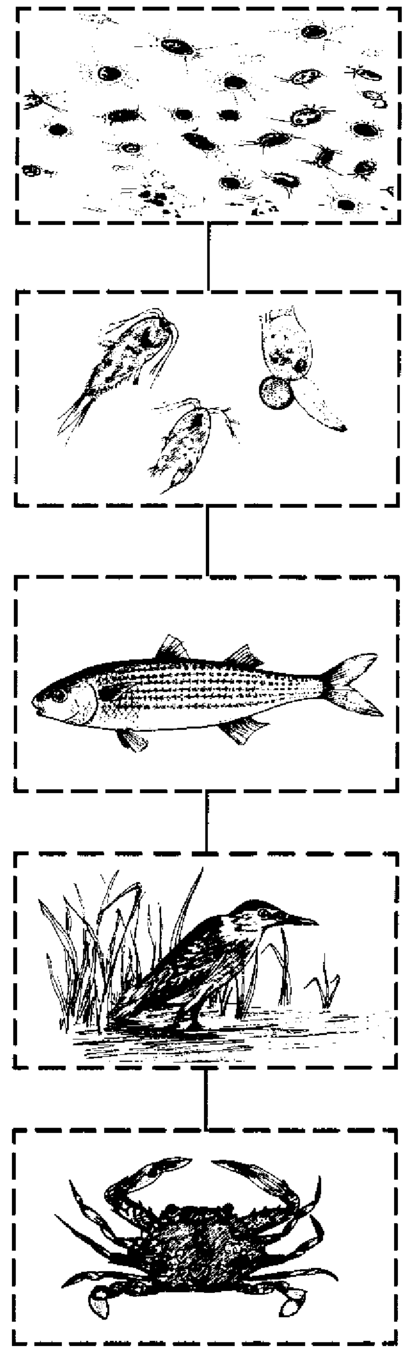
Students create a fishpond "recipe" with all the "ingredients" needed for a fishpond and then play a fishpond card game to assemble fishpond food chains.

Time

2 class periods

Skills

reasoning, looking for patterns and relationships



A sample food chain.

Assessment

Students:

- Diagram a fishpond food chain with labels for the producers, herbivores, omnivores, carnivores and decomposers.
- Write a description of the food chain that:
  - explains how "energy" is needed for all organisms to stay alive and grow;
  - identifies organisms that are reproducing, growing, dying and decaying.

Vocabulary

ecosystem – a system formed by the interaction of a community of organisms with their environment
food chain – a series of organisms interrelated in their feeding habits; the smallest being fed upon by a larger one, which in turn is eaten by an even larger organism
producer – plant that makes its own food using energy from the sun
consumer – organism that feeds on other organisms
herbivore – animal that eats plants
carnivore – animal that eats other animals
omnivore – animal that eats both plants and animals
decomposer – organism that feeds on dead plants and animals and helps break them down into nutrients to be used again
phytoplankton – the plant organisms in plankton
plankton – tiny floating or drifting organisms in a body of water
zooplankton – the animal organisms in plankton

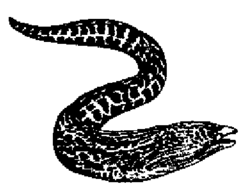
Materials

Provided:

- pond life cards (in Appendices)

Needed:

- newsprint chart
- colored markers
- string and tape
- five small bowls
- a large, clear bowl
- a large spoon
- snacks for "Fishpond Ecosystem Mix" (Optional: See suggestions at end of activity.)



Producers (green)	
Herbivores (blue)	
Carnivores (red)	
Omnivores (orange)	
Decomposers (yellow)	
Nonliving (brown)	

Advance Preparation

Using colored markers or colored paper, prepare and post a chart showing each component of the pond as a different color (see sample above). Copy and cut out the pond life cards. Make three sets of producer cards and save two sets for the game in this activity. Place the cards in five separate bowls by group (producers, herbivores, omnivores, carnivores and decomposers); remove the labels so that the groups are not identified.

Background

Plants are producers; they convert the sun's energy to food energy. In the fishpond, the main producers are microscopic phytoplankton and limu (algae). Herbivores (plant eaters), such as the tiny zooplankton and certain fish, get their energy from the producers. In turn, the herbivores are eaten by carnivores (meat eaters). Herbivores and carnivores are also referred to as primary and secondary consumers. When plants and animals in the fishpond die, scavengers and deposit feeders like crabs feed on them and recycle the nutrients so that the plants can continue to grow. Waste products from animals in the pond are also recycled back into the system from the activities of decomposers.

Sample Food Chains

Note: The arrows indicate the flow of nutrients from the producers through the consumers and back into the ecosystem through the decomposers.

Producers	Herbivores	Omnivores	Carnivores	Decomposers
limu manauea (ogo)		ʻalae keʻokeʻo (Hawaiian coot)		kūhonu (white crab)
phytoplankton	ʻamaʻama (striped mullet)		kākū (barracuda)	kūhonu (white crab)
phytoplankton	awa (milkfish)		ulua (giant trevally)	moʻala (long-eyed swimming crab)
limu kala	pualu (surgeonfish)		pūhi (moray eel)	pāpaʻi (blue pincher crab)
phytoplankton	zooplankton	ʻoʻopu (goby)	aukuʻu (black-crowned night heron)	ʻōpae ʻoehaʻa (freshwater prawn)
phytoplankton	nahawele (mussels)		aloalo (mantis shrimp)	pāpaʻi (blue pincher crab)

Teaching Suggestions

1. Divide the class into five teams and give each team one of the five bowls you have prepared. Explain that each of these bowls has one kind of "ingredient" that will be needed to make a "recipe" for a fishpond.

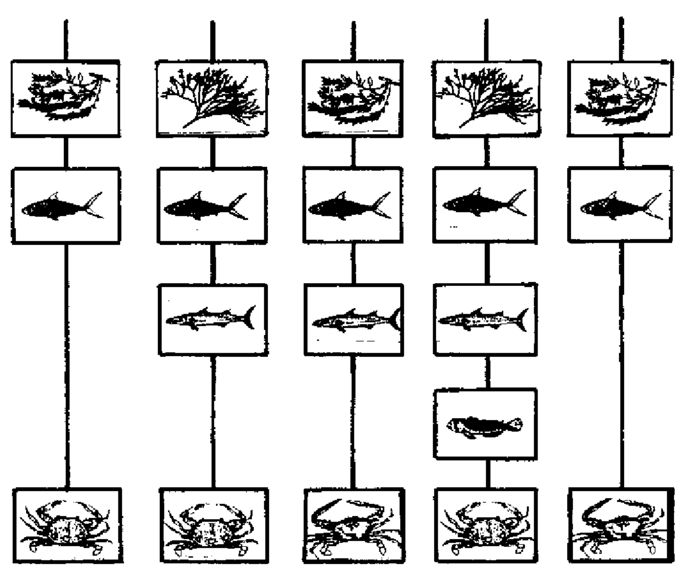
2. Challenge students to read the information on the cards in their bowls and discover what the organisms have in common. Then ask them to come up with a definition for their group of organisms. Ask them to place their definitions in the correct category (producer, herbivore, omnivore, carnivore, decomposer) on the chart you have prepared.

3. Display the large, clear bowl to represent the fishpond. As a class, come up with a fishpond recipe using the "ingredients" in each group's small bowl. As each ingredient is discussed, have students place those cards in the large bowl.

   A Sample Fishpond Recipe
   - Begin with nonliving "ingredients" to establish the setting for the pond—rocks for the walls, sea water, stream and protective reef.
   - Add the limu (producers) who make their food using energy from the sun and review the process of photosynthesis that makes this happen.
   - Add herbivores to feed on the plants.
   - Combine with carnivores to feed on the herbivores and omnivores to feed on both plants and animals.
   - Stir in some decomposers to break down the dead plants and animals and to recycle the nutrients for the producers to use again.
   - "Cook" using energy from the sun.

4. Label the large bowl the "fishpond ecosystem" and discuss the concept of an ecosystem. To reinforce students' understanding of how each group of organisms is related to the others, play a "Go Fishing" card game. See rules for the game at the end of this activity.

5. When students have completed the game, have teams work together to make a display of the food chains they created. Give each team a section of string, some tape and a sheet of construction paper for each colored category on the chart. Ask students to tape each pond card to the appropriate color construction paper. They may also choose to color their organisms using the information provided on the card or referring to reference materials suggested. Then have them hang their strings vertically over the chart and tape the cards onto the string in a food chain. See diagram.



6. Discuss where humans fit into these food chains.

   Discussion Questions

   - If you were managing a fishpond would you grow herbivores, omnivores or carnivores in your pond? Why?
     (herbivores or omnivores)
   - What are the advantages of growing herbivores?
     (There is a higher population of these fish in an ecosystem than carnivores because herbivores feed at a lower level on the food chain, which is one reason that Hawaiians grew awa and ʻamaʻama in their ponds.)
   - Are the rocks in the pond considered living or nonliving? What is the traditional Hawaiian view of rocks?
     (In the traditional Hawaiian view, there is no division between the sky, sea, land, human, rock, trees, birds, or animals; all were considered as living and things to be revered.)
   - Should we add a moʻo wahine to our fishpond recipe? What do you know about the presence of moʻo in fishponds?
     (Moʻo wahine were spiritual guardians that Hawaiians believed lived in the fishponds. They were rarely seen by humans, except those who lit fires on the walls of the fishponds close to the home of the moʻo. Prayers were offered to the akua moʻo for the welfare of the people and to make the fish plentiful.)

7. Have students complete the assessment activities – the fishpond food chain diagram and written summaries. Ask them to include humans in the diagrams to show where they fit in the food chain as well.

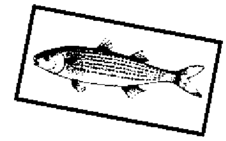
Adaptations/Extensions

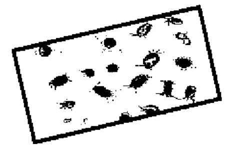
- Create a "Fishpond Ecosystem Mix" snack to reinforce concepts presented in this activity. Give students some of the following ingredients to create their own ecosystem mix: nonliving components (cereal such as Rice Krispies); producers (furikake); herbivores (goldfish crackers); carnivores (gummy worms to be eels); decomposers (shrimp chips to be shrimp.) Thanks to Susan Miyamoto for this suggestion!
- Ask students to conduct research to find moʻolelo (legends) related to the moʻo that lived in fishponds in your area. They might also research the significance of the Kū and Hina stones in the fishponds. (See the activity *Haku Mele Aloha* in Unit 3 for more information about these stones.)
- Ask each student to research one of the fishpond organisms, find at least three interesting facts about it and draw a color image of it. Have students report their research to the class and then work together to create a class bulletin board of a fishpond ecosystem using students' drawings.
- Visit the Kāhea Loko Website (www.thepaf.org) to view beautiful color photographs of the microscopic life forms that inhabit the pond—the phytoplankton and zooplankton. Have students draw some of these organisms and add them to their fishpond ecosystem.
- Have students sort the pond life cards by endemic, indigenous and introduced species. Discuss the differences in these categories (see Glossary) and ask students to conduct research into the impact of introduced marine organisms in the Islands. See http://www2.bishopmuseum.org/HBS/invertguide/index.htm for an online copy of "Guidebook of Introduced Marine Species of Hawaiʻi."

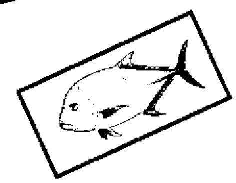
"Go Fishing" Game — Instructions

Objective

To win the most points by collecting cards to make food chains







Scoring

3 points:

producer — herbivore or omnivore — decomposer

4 points:

producer — herbivore or omnivore — carnivore — decomposer

Game Set-up

Add two more sets of producer cards to the fishpond ecosystem bowl and stir them up. Divide the class into five groups. [Optional: Before using the cards to play the game, have students label the cards with a letter P, H, O, C or D so that they may easily identify whether or not they have a producer, herbivore, omnivore, carnivore or decomposer card.]

To Play

Each team has one student fish two cards from the fishpond bowl (with eyes closed).

- Teams organize and study their cards to see what they need to complete a food chain.

  (Note each card has information on what the organism eats and/or is eaten by. For the purpose of this game, teams only need to assemble a chain with a card from at least three categories. See Scoring above.)
- Teams conceal their cards from other teams. Taking one turn at a time, each team selects another team to ask for a producer, herbivore, carnivore, omnivore or decomposer card.*
- If the team asked has a card, the team must hand over the card to the team requesting it.
- If the team does not have a requested card, they instruct the other team to "go fishing." The team then fishes one card from the fishpond bowl (with eyes closed).
- If a team has enough cards (at least three) for a food chain, the team places those cards down and fishes for two more cards from the bowl.

*Note: Each team takes only one turn at a time whether they succeed in collecting a card from another team or are instructed to "go fishing."

To End the Game

Once all cards are fished from the bowl, add up points for completed food chains. (A score sheet may also be tallied while the game is being played.)

Lōkahi Game

- How are plants and animals in a fishpond dependent on one another? How is lōkahi (balance) maintained in a fishpond?

Hawai'i DOE Content Standard

Science: Organisms and Development – Interdependence

- Students describe, analyze, and give examples of how organisms are dependent on one another and their environments.

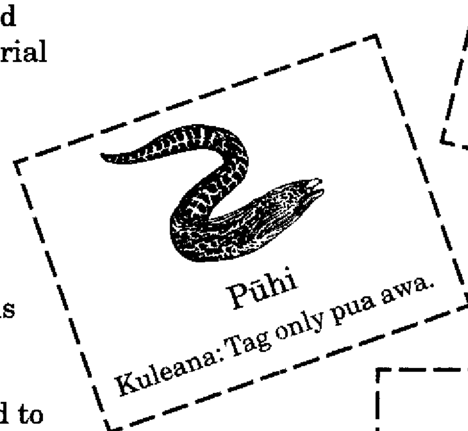
Grades 4 - 5 Performance Indicators

Grade 4

- Examine how organisms depend on dead plant and animal material for food.
- Give examples of organisms responding to a changing environment.

Grade 5

- Identify how plants and animals depend on each other in the exchange of nutrients.
- Explain how organisms respond to a constantly changing environment.
- Explain how changes in a specific niche affect the population of organisms living there.



Key Concepts

- Energy flows through a fishpond and nutrients are recycled by means of a complex series of food chains that make up a food web.
- All parts of the food web are interconnected. A change in the environment may affect the lōkahi (balance) of the fishpond.

Prerequisite

Recipe for a Fishpond

Activity at a Glance

Students play a game that illustrates how plants and animals in a fishpond are interdependent and how lōkahi (balance) is maintained through this interdependence.

Assessment

Students write an explanation of how lōkahi (balance) is maintained in the fishpond. Their explanations should include:

- how organisms depend on nutrients made available from the pond's decomposers; and
- how plants and animals depend on each other in the exchange of nutrients.

Time

2 class periods

Skills

reasoning, looking for patterns and relationships

Vocabulary

lōkahi – balance; unity
food chain – a series of organisms interrelated in their feeding habits; the smallest being fed upon by a larger one, which in turn is eaten by an even larger organism
food web – a series of organisms related by predator-prey activities
limu – seaweed
limu kalawai – freshwater pond algae
niche – the ecological role of an organism
nutrients – any matter that, taken into a living organism, serves to sustain it, promote growth, replace loss, and provide energy
pua awa – juvenile awa (milkfish)
kākū – barracuda fish
pāpio – young ulua or jack fish (less than 10 pounds)
pūhi – eel
mākāhā – sluice grate or gate, as in a fishpond
loko kuapā – seawater fishpond with rock walls built on a reef flat
kuleana – responsibility
Sidereal day – the time it takes the Earth to spin once around on its axis relative to an inertial reference system (23 hours, 56 minutes and 4 seconds)

Materials

Provided:
- kuleana cards

Needed:
- 1 bag of popped popcorn
- 1 box of small sandwich bags
- whistle or pū
- colored paper (6 different colors for game cards)
- yarn or string (to make game cards for students to wear)
- small box (to hold extra game cards in the "pond nursery")
- natural materials (to outline a "pond" on the school grounds)
- glue

Advance Preparation

- Duplicate the kuleana cards and glue each type of card onto a different colored paper. Punch two holes in the tops of the cards and place string or yarn through them so that students can wear them around their necks during the game. (Laminating the cards is advised.)
- Gather materials and outline the playing area—the loko kuapā, which should be located in an open grassy area of your school ground. You may want to use safety cones, coconut fronds, or any other type of marker to outline the pond. (See diagram included in the Game Instructions.)
- Draw a copy of the game set-up on the classroom board. (See Game Instructions.)

Teaching Suggestions

1. Review the concept of a food chain using plants and animals from the fishpond. Introduce the term "niche"—the ecological role that an organism plays. For example, the niche of the kākū (barracuda) in the fishpond is the role of a carnivore. This carnivore helps to keep the population of smaller fish in balance.

2. Introduce the Lōkahi Game to students and distribute the kuleana (responsibility) cards. Review the cards and discuss the role that each student will play in the game. Have students place the cards around their necks.

3. Show students the Lōkahi Game diagram and explain where each player will begin the game. Review the game rules (on the following page).

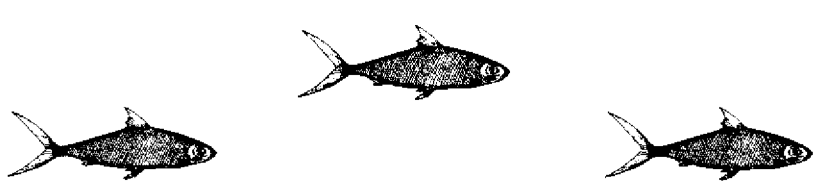
4. Take the class outside to a large clear area and play the game.

5. After each round, read a ho'ā'o (chance) event from the list provided and follow the instructions. Discuss what happens to lōkahi (balance) in the pond with each event.

   Discussion Questions

   - What would happen if there were no herbivores?
     (There would be too many producers and no food for carnivores.)
   - What happens in the pond when there are not enough carnivores?
     (The population of fish could grow too large and not have enough food to eat.)
   - What would happen to the fishpond ecosystem if no organisms filled the niche of decomposers?
     (The stored nutrients in dead plants and animals would not be broken down and recycled back into the pond for the producers to use.)
   - How many food chains can we construct from the kuleana cards used in this game? How do these food chains combine to make a food web?

6. Ask students to complete the assessment activities – illustrate a fishpond ecosystem and show how nutrients are exchanged and recycled and how lōkahi is maintained.



Adaptations/Extensions

- Conduct a food web demonstration with your students using the pond life cards and a ball of string.

  a) Choose one student to represent the sun, and give him or her the ball of string. Explain that the string represents energy, which comes from the sun and supports life.

  b) Give each of the other students a picture of a fishpond inhabitant.

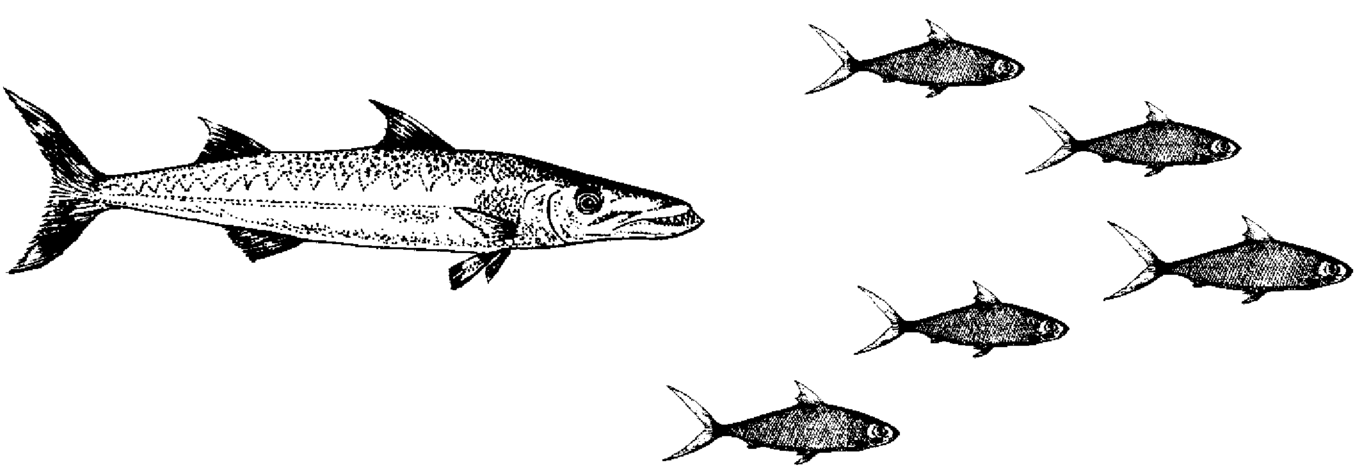
  c) Demonstrate a food chain by having the sun pass its energy to a producer such as algae. Holding the end of the string, the "sun" will toss the ball to the "producer." The producer will use the energy to make nutrients and toss the rest of the ball (pass the nutrients) to a herbivore who will then pass it to a carnivore. The carnivore can then die and pass the nutrients to a decomposer.

  d) Have all of the students, including the sun, stand in a large circle. Repeat the food chain exercise. When you come to the end of the food chain, the decomposer can pass the string back to the sun, who will toss it to another plant. The students should read their cards and decide who might get their nutrients. (There may be several possible correct choices.) When tossing the ball of string to the next person, the students should keep hold of the string and toss the rest of the ball. In this way, you will build a visible web. Keep going until all of the students are holding at least one section of string.

  e) Explain that this represents a food web – a complex, interlocking series of food chains. This is still a very simple web – in nature, real food webs are much more complicated.

  f) When the food web is complete, have the students take a couple of steps backward until there is tension on all the strands of the web. Ask the students what would happen if you were to remove all of the predators from the web. Keeping tension on the web, ask all of the predators to drop their string at the same time. What happens? Why?

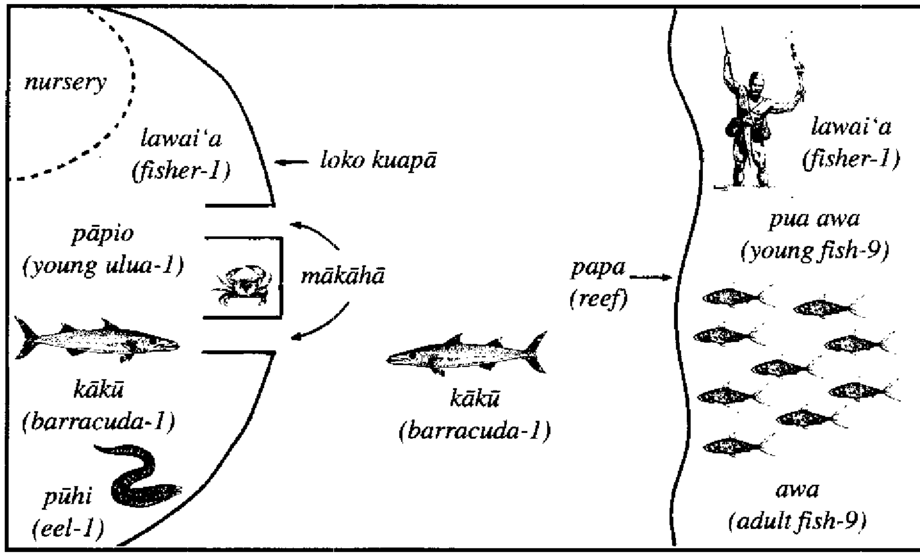
- Revisit the K-W-L Chart from Unit 1 and have students add information that they have learned from this unit and questions they would still like to pursue in their study of fishponds.



Lōkahi Game — Instructions

Objective

To obtain the "nutrients" needed to survive and to increase productivity in the pond



Game Set-up

Have students stand in their designated areas in or outside the loko kuapā. Distribute a colored kuleana card and a plastic bag to each player. Sprinkle popped popcorn around the playing area inside the loko kuapā to represent the limu in the pond. Place 9 adult awa cards in a box in the nursery.

No. of Players	Start game in	Kuleana (Responsibility)
9 adult awa (fish)	reef	To avoid being tagged by the lawai'a or the kākū and to gather limu (popcorn) and place it in "stomach" (small plastic bag)
9 pua awa (young fish)	reef	To move through the mākāhā to the loko kuapā's nursery without being tagged by the pāpio or the pūhi and to gather limu (popcorn) and place it in "stomach" (bag). To "grow" into an adult awa in the nursery and avoid being tagged by the lawai'a and kākū
2 lawai'a (fisher)	1 in reef 1 in pond	To tag adult awa needed for food and collect nutrients (plastic bags with popcorn)
1 Hawaiian crab (teacher)	on pond wall	To recycle nutrients after each round by adding limu (popcorn) to the pond
1 pūhi (eel)	on rock wall in mākāhā	To tag as many pua awa as possible and collect nutrients (plastic bags with popcorn)
2 kākū (barracuda)	1 in pond 1 in ocean	To tag as many adult awa as possible and collect nutrients (plastic bags with popcorn)
1 pāpio (young ulua)	1 in pond	To tag as many pua awa as possible and collect nutrients (plastic bags with popcorn)

Lōkahi Game — Instructions (cont.)

To Play

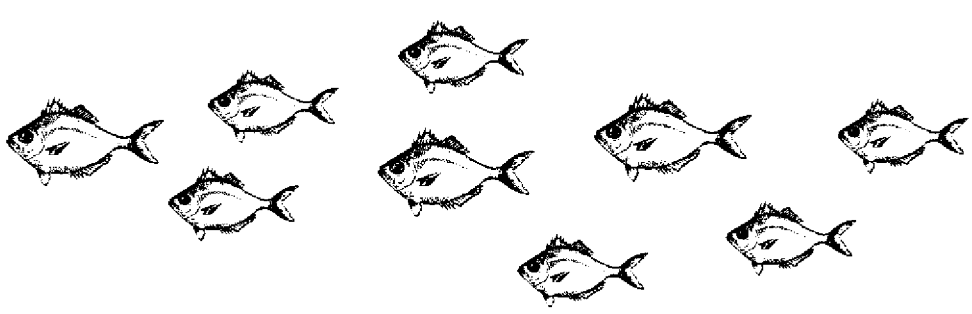
- Only the pua awa (small fish) may enter the pond and only through the mākāhā.
- All players must obtain "nutrients" to survive. The popcorn on the ground represents limu and only the herbivores (awa and pua awa) may harvest it directly.
- The carnivores (kākū, pāpio, pūhi, lawai'a) obtain nutrients by tagging the awa. When they tag the awa, they take the "stomach" (plastic bag) from the tagged fish and that fish sits out for one round.
- The kākū and lawai'a may tag only the adult fish (awa). The pāpio and pūhi may tag only the juvenile fish (pua awa). If these carnivores tag the wrong size fish, they must sit out for one round.
- The nursery is only for the pua awa and is a safety zone where they may not be tagged. They may only remain in the nursery for 10 seconds before "morphing" into an adult awa (changing tags) and returning to the pond.
- The teacher will begin and end each 30-second round by blowing a pū or whistle.
- At the end of each round:
  - all players without food in their "stomachs" have not survived and must sit out for the next round;
  - the teacher will play the role of the Hawaiian crab and will "recycle" nutrients by adding a few kernels of popcorn to the pond for each fish that died; and
  - players will see how many fish remain in the pond and discuss how rules and/or numbers of herbivores or carnivores may need to be modified.

Ho'ā'o (Chance) Events

After each round, read one of the ho'ā'o events and adjust the numbers of players according to the directions. Play a round and then discuss how this event affected the life in the pond.

To End the Game

The game ends when all ho'ā'o events have been played out.



Lōkahi Game — Hoʻāʻo (Chance) Events

1. A yellow foam appears on the surface of the loko kuapā. The mo'o wahine (spiritual guardian) of the pond was seen just hours before the foam surfaced. For fear of bitter tasting fish, the konohiki (chief) has advised that no fish may be caught in the pond. *All lawaiʻa must sit out for one round.*

2. There are too many adult awa crammed into the sluice. The sun is fierce. If the fish that are exposed are not removed immediately, they could bake. *Remove 3 adult awa from the pond for one round.*

3. The konohiki (chief) recently dreamed that the fishpond would be depleted of fish if the āholehole were eaten. Unknowingly, the kia'i's (pond guardian's) son trapped a large āholehole and ate it for lunch. *All fish from the pond disappear for one round.*

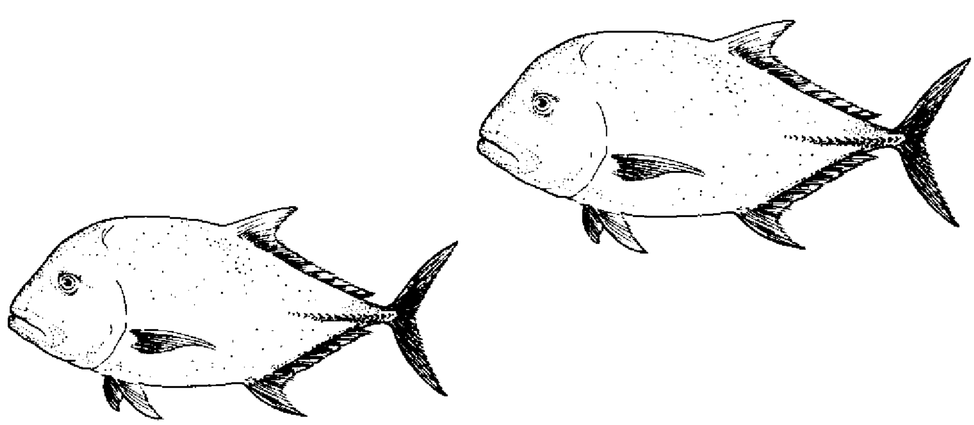
4. A tidal wave occurred and the wall of the loko kuapā was partially destroyed. The kākū swam away. The aliʻi has ordered the makaʻāinana (commoners) to rebuild immediately. *For one round, the kākū must sit out, and all lawaiʻa must sit out to help restore the pond's wall.*

5. The aliʻi is visiting a neighboring chief. He has ordered his fish courier, Makoa, to bring him a fresh moi from the aliʻi's loko kuapā. Makoa delivers the fish still alive. The aliʻi is satisfied and as a gift, three fish can be taken for consumption. *Remove 3 adult awa and 1 pāpio from the pond for one round.*

6. The mākāhā is in need of repair. The konohiki has ordered that ʻōhiʻa ʻai and lama wood be collected to repair the grate. *All lawaiʻa must halt fishing for two rounds to help with the pond repairs.*

7. The aliʻi is planning an ʻahaʻaina (feast). He has ordered that several fish be caught and prepared for the imu (underground oven). The kiaʻi (pond guardian) is responsible for organizing the fish catch. *Remove 6 adult awa from the pond.*

8. It is the high tide of ʻOle. The ʻauwai kai is filled with fish. A dog makes his way to the pond and steals fish. *Remove the 1 adult awa from the pond for one round.*



Kuleana Cards

Make 2 copies of this page. (9 cards needed for game)

Pua Awa (Juvenile Fish)

Kuleana: Get to the nursery without being tagged by the pāpio or pūhi. Grow into an awa. Find limu to place in your stomach.

Pua Awa (Juvenile Fish)

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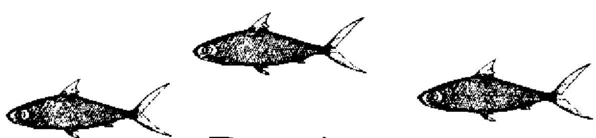

Pua Awa (Juvenile Fish)

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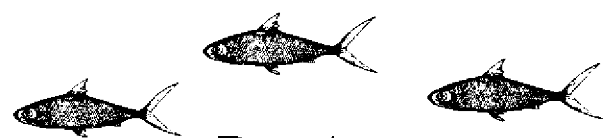

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Pua Awa (Juvenile Fish)

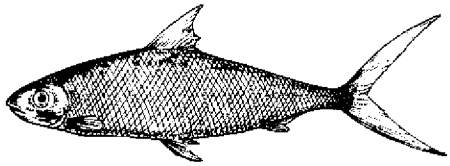
Kuleana: Get to the nursery without being tagged by the pāpio or pūhi. Grow into an awa. Find limu to place in your stomach.

Instructions

Copy the cards and mount onto colored paper (a different color for each species), laminate, punch two holes in the top and tie with string or yarn (for students to wear around their necks).

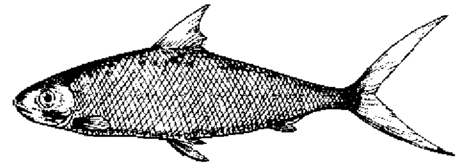
Kuleana Cards

Make 3 copies of this page. (18 cards needed for game)



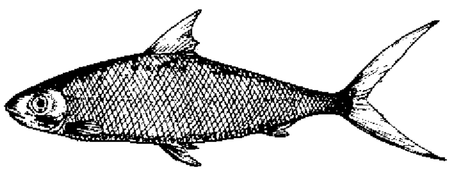
Awa (Adult Fish)

Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.



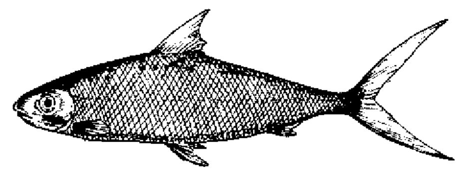
Awa (Adult Fish)

Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.



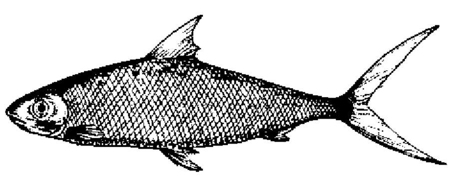
Awa (Adult Fish)

Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.



Awa (Adult Fish)

Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.



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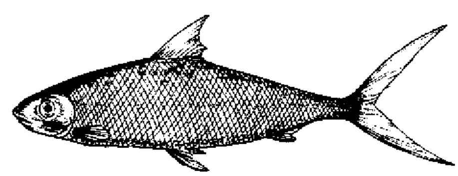
Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.



Awa (Adult Fish)

Kuleana: Avoid being tagged by the lawaiʻa or the kākū. Find limu to place in your stomach.

Kuleana Cards

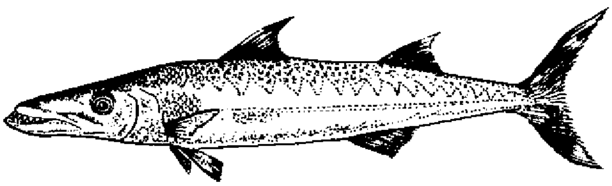
Make 1 copy of this page.

(2 lawai'a cards needed for game.)

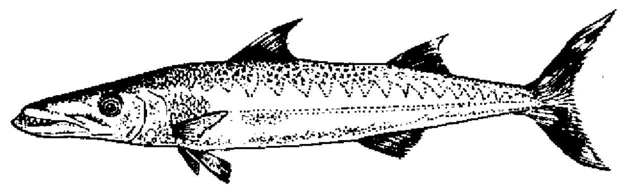
Lawaiʻa
(Fisher)
Kuleana: Tag only adult awa.

Lawaiʻa
(Fisher)
Kuleana: Tag only adult awa.

(2 kākū cards needed for game.)

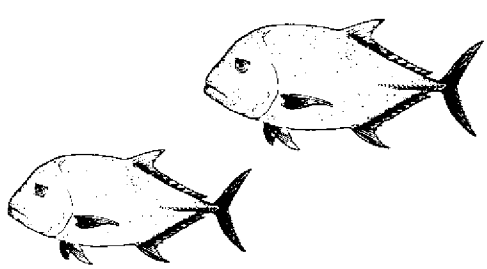


Kākū
(Barracuda)
Kuleana: Tag only adult awa.

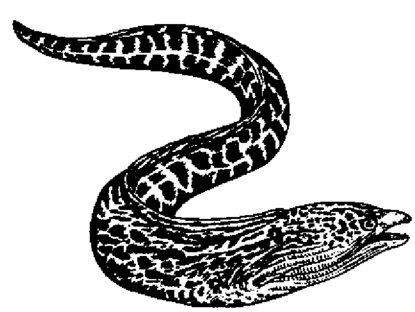


Kākū
(Barracuda)
Kuleana: Tag only adult awa.

(1 pāpio & 1 pūhi card needed for game.)

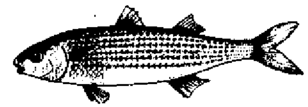


Pāpio
(Young Ulua)
Kuleana: Tag only pua awa.



Pūhi
Kuleana: Tag only pua awa.

Unit 2 at a Glance



Grades 6 - 8

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: Earth in the Solar System Students describe how the Earth's motions and tilt on its axis lead to changes in seasons.	**2C.** How do Earth-Sun-Moon relationships create seasons and tides? How do marine organisms respond to changes in seasons and tides? **Activity: *Seasons and Tides: Marine Responses to Celestial Changes***	• Earth-Sun-Moon relationships create seasons and tides in Hawai'i that affect the behavior of marine life.	Students: • Diagram how Earth-Sun-Moon relationships create seasons and tides. • Write a fishing tale based on an interview with a fisher that summarizes how seasonal and tidal changes affect marine life.
Science: Doing Scientific Inquiry Develop questions and hypotheses that can be answered through scientific investigations. **Science: Cycle of Matter and Energy Flow** Explain how plants use the energy from sunlight and matter from the atmosphere to make food.	**2D.** How do the tides affect the growth of phytoplankton and the level of dissolved oxygen in a fishpond? What other factors affect the growth of phytoplankton? **Activity: *Kai Moku: The Turn of the Tide***	• Phytoplankton uses energy from the sun and nutrients from fish wastes to make food. • Tidal circulation helps prevent accumulation of wastes that leads to stagnation and loss of dissolved oxygen needed by fish.	Students: • Write a scientific report describing the hypothesis, prediction, methodology and results. • Diagram how phytoplankton uses energy from the sun and nutrients from fish wastes to make food.

Culminating Activity

Students work in pairs or small groups to create a seasonal change calendar (one month for each pair of students) that highlights lunar and seasonal changes and includes conservation notes for harvesting marine species.

Materials needed: 12 sheets of poster-size paper, preferably paper that can receive watercolor paint, crayons (light colored and bright; neon colors are best), watercolor paints (Crayola brand works well; the colors are bright and brilliant), yardstick, and calendar cards (provided at the end of this unit)

Calendar pages should include:

- Color illustration of at least one species featured on the calendar card that depicts how the plant or animal responds to the season*
- Conservation notes about harvesting one of the species noting seasonal fishing regulations and students' recommendations for any additional conservation practices; (Encourage students to include feedback from the community about their ideas for conservation.)
- Moon phases for the month, indicating days of new, full and quarter moons; (Add tide information using a tide chart, if desired.)
- ʻŌlelo noʻeau (Hawaiian proverb) related to the time of year; (Samples provided on calendar cards may be used, or students may research others.)

Culminating Activity (continued)

Direct students to information on current Hawai'i fishing regulations at the Hawai'i Division of Aquatic Resources Website: http://www.hawaii.gov/dlnr/dar. Additional references to obtain more information about species on the calendar cards are listed in the Appendices. See Additional Resources and pond life cards.

Teachers' Note: The calendar cards provided for this activity list the Hawaiian months as coinciding with the months used in modern-day calendars. These are only rough approximations since in ancient times the months were marked by the appearance of different stars and constellations in the eastern sky at sunset. Some of these celestial appearances are listed on the cards to provide additional information to students. Also, different islands had divergent naming of months. The names chosen on the calendar cards are based on *Hawai'i: A Calendar of Natural Events* (Foster et al., 1988), which match month names for Hawai'i island. Encourage students to research the Hawaiian month names specific to their island or refer them to the information provided at the end of this unit. Note that some of the 'ōlelo no'eau may refer to events that are not as common today due to alteration of coastal habitat and its effect on native species.

*Field test teacher, Zennie Sawyer at Kilohana School had her students create crayon-resist drawings for their calendar pages. The colorful result was beautiful.

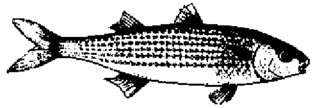
Creating Crayon-Resist Illustrations

1. Have students draw the picture at the top of the calendar page lightly in pencil so that the pencil marks won't show after painting. Drawing should use lots of line repetition in contour patterns (similar to the contour lines on Hawaiian quilts) for the best effect of the technique.
2. Go over the pencil drawing with crayons. Use light, bright colors rather than dark colors. Crayon markings must be heavy. Students need to think ahead and select crayon colors and paint colors that will contrast. (Using blue paint on blue crayon will not be effective!) The more contrast that the students use, the better and the more outstanding their results will be. Students may have to get over their mindset of green lines and green paint for mountains; they should experiment with pink or orange lines with rich dark green paint. The effects are outstanding, even if it sounds wierd at first! It would be wise to have students experiment with the technique to see the beauty of colors that they can obtain. Don't overlook the use of white crayon, even though you can't see it on white paper. Once painted over, white shows up strikingly for waves or wind.
3. Go over the crayon markings with contrasting paint colors. Encourage students to use minimal strokes in applying the paint and not to overdo the application of paint or it will rub through. Mix rich dark colors that will contrast with the crayons. And avoid using dark crayon colors with dark paint. Do not paint one color over the whole drawing; think through the picture and use multiple colors.

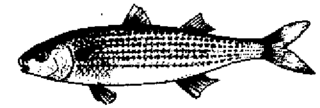
Mahalo, Zennie!

Review criteria for assessing students' work (see sample rubric on the following page).

Ask students to present their calendar pages to the class with the name of the month covered. Challenge their classmates to listen carefully to the information and see if they can determine which month is being presented. Post the calendar pages around the room or in a central area of your school. Set aside times to review the calendar each month and encourage students to add their observations of seasonal changes.

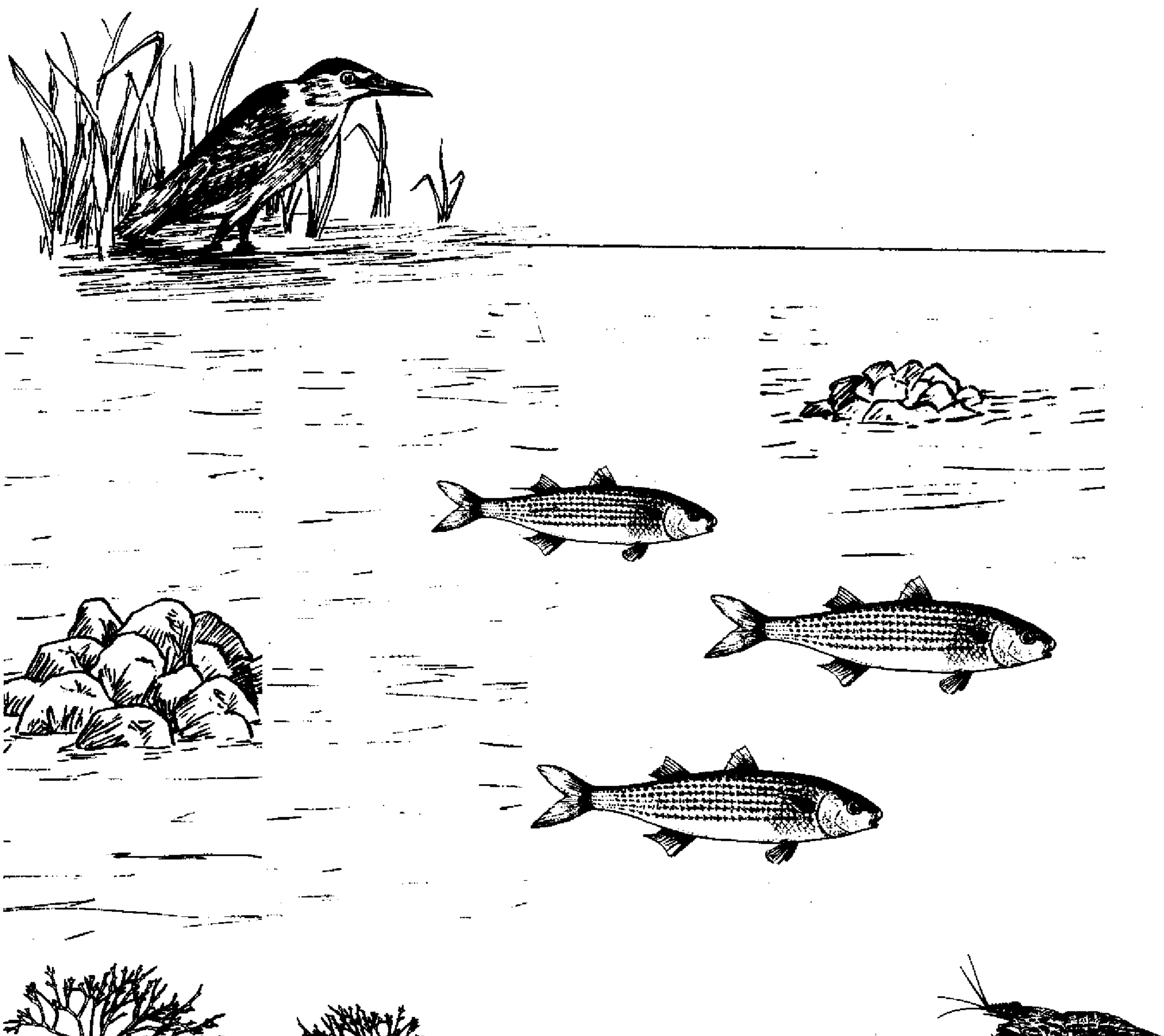


Sample Rubric for Culminating Activity



Performance Indicators	Kūlia Exceeds Standard	Mākaukau Meets Standard	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Science: Earth in the Solar System Explain how seasonal changes of light intensity affect marine life. ***Points*** _____	Calendar page illustration and/or description clearly shows how two different marine species respond to seasonal change.	Calendar page illustration and/or description clearly shows how a marine species responds to seasonal change.	Calendar page illustration and/or description does not clearly show how a marine species responds to seasonal change.	Calendar page illustration and/or description depicts a marine species but does not show how it responds to seasonal change.
Science: Mālama I ka ʻĀina - Conservation of Resources Discuss and evaluate present natural resource conservation practices and propose additional practices relevant to the community. ***Points*** _____	Presentation includes accurate information and skillful discussion and evaluation of current fishing regulations. Ideas for additional conservation practices are relevant and include feedback from the community.	Presentation includes accurate information and understandable discussion and evaluation of current fishing regulations. Ideas for additional conservation practices are relevant and thoughtful.	Presentation includes accurate information but needs prompting and focus to clearly discuss and evaluate current fishing regulations. Ideas for additional conservation practices need to be more developed.	Discussion and evaluation of current fishing regulations is unclear or inaccurate. Ideas for any additional conservation practices are not presented.
Effort/Task Commitment ***Points*** _____	Rigorous effort; shows commitment to strive for best work	Appropriate effort; successful in completing task	Inadequate effort for completing task	Minimal effort; unsuccessful in completing task

I NOTICED:



Seasons and Tides:

Marine Responses to Celestial Changes

- How do Earth-Sun-Moon relationships create seasons and tides?
- How do marine organisms respond to changes in seasons and tides?

Hawai‘i DOE Content Standard

Science: Earth in the Solar System

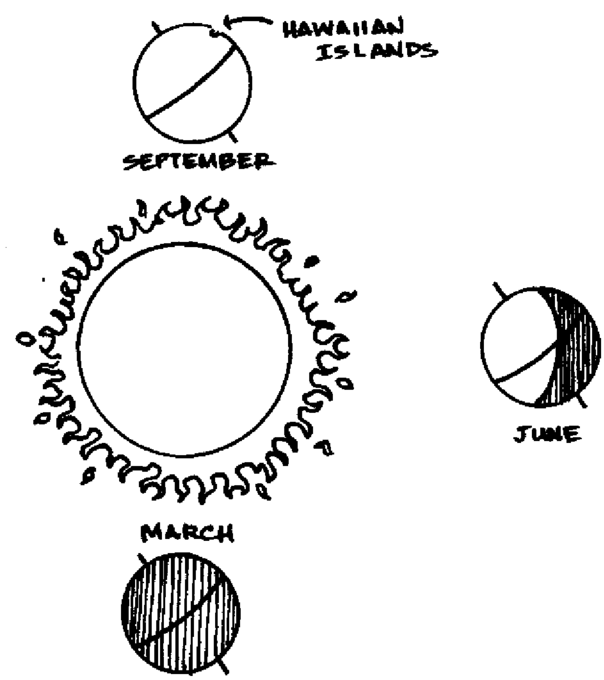
- Students discuss how the Earth-Sun-Moon system causes seasons, moon phases, climate, weather and global changes.

Grades 6 - 8 Performance Indicators

- Diagram the Earth's rotation and revolution around the Sun.
- Demonstrate the cause and effect relationship between the Earth's rotation/tilt of its axis and the change in seasons.
- Explain how seasonal changes of light intensity affect marine life.

Key Concept

Earth-Sun-Moon relationships create seasons and tides in Hawai‘i that affect the behavior of marine life.



Activity at a Glance

Groups of students teach one another how Earth-Sun-Moon relationships create tides and seasons.

Skills

observation, research, oral communication

Assessment

Students:

- Diagram how Earth-Sun-Moon relationships create seasons and tides.
- Write a fishing tale based on an interview with a fisher that summarizes how seasonal and tidal changes affect marine life.

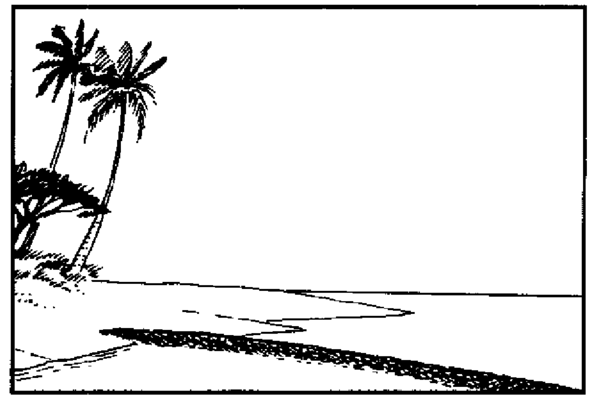
Time

3 - 4 class periods

Vocabulary

spawning – producing or depositing eggs
larva – early life form that is fundamentally unlike parent and metamorphoses to become adult
ʻōlelo noʻeau – Hawaiian proverb
kau wela – the hot, dry season in Hawaiʻi from May through September
hoʻoilo – the wet, cool season in Hawaiʻi from October through April

Materials



Provided:
- student information sheets
- Hawaiian Moon calendar

Needed:
- lamp with 100 watt light bulb
- globe
- softball
- tide chart for Hawaiʻi

Advance Preparation

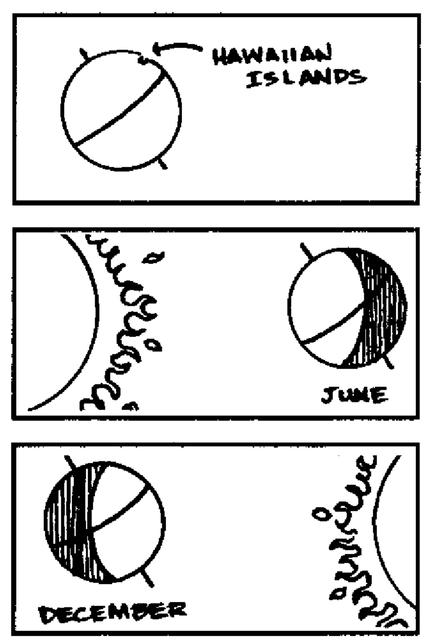
Copy the information sheets (one sheet for each of four groups). Note that two groups will have the same sheet on tides; assign one to complete the task for Group A and one to complete the task for Group B.

Background

The Earth rotates about an imaginary line that passes through the north and south poles of the planet. This line is called the axis of rotation. Earth's rotational axis always points in the same direction, so that the North Pole points towards the star Polaris or the North Star. Think of the Earth as a spinning top, tipped over to one side at an angle of 23.5 degrees.

For an observer at a fixed position on Earth, the rotation of the Earth makes it appear as if the sky is revolving around the Earth. In other words, if one is standing for long enough in a field at night, it looks like the sky is moving, not the Earth.

The tilt of Earth's rotational axis and the Earth's orbit work together to create the seasons. As the Earth travels around the Sun, it remains tipped in the same direction, towards the star Polaris. This means that sometimes the northern half of the Earth is pointing towards the Sun (summer), and sometimes it is pointing away (winter). These points in the Earth's orbit are called solstices. Notice that when the northern hemisphere is tilted towards the Sun, the southern hemisphere is tilted away. This explains why the hemispheres have opposite seasons (UCAR, 2000).



The tilt of Earth's rotational axis and the Earth's orbit work together to create the seasons.

The rotation of the Earth on its axis (every 23 hours and 56 minutes and 4 seconds, or Sidereal day) and its annual revolution around the Sun create fluctuations in tides, currents, day length (the hours of light) and temperature that affect the behavior of marine life. (The solar day of 24 hours measures the time between the moment of sunrise and the same moment the next day.) Hawaiians were keenly aware of these natural rhythms and they timed their fishing and harvesting practices accordingly. Today, Hawaiian proverbs and traditional knowledge provide a window to the past where the daily activities of the early Hawaiians were centered around celestial and biological rhythms.

Hawaiian Moon Calendar

The Hawaiian Moon calendar was developed over the centuries by the ancient Polynesians, whose lives literally depended on their ability to catch fish. The Polynesians discovered that the biological clocks of all life forms resonate in predictable relationships with the Earth, Sun and Moon and they were able to forecast the times of heightened activity for all forms of sea life wherever they were (Rothery, 2003). It was the duty of the kilo lani (astronomers) to keep the annual calendar and watch the moon to determine when certain kapu should be placed on the fish or land. Some say that the kilo lani knew when to add extra days or an extra month to the moon calendar at the end of the Makahiki so that the seasons would correspond with the Sun. Kilo lani on the different Islands and the different moku (districts) had various methods of adjusting, as the name of the lunar months vary on each Island (Taylor, 1995).

The Hawaiian time frame for a day included the period from sunset to sunset rather than from sunrise to sunrise, and a day might not be a full twenty-four hours. The Hawaiian calendar actually alternated months of thirty days with months of twenty-nine days. Having established thirty days (one of them half as long as the other twenty-nine), the monthly calendar was further divided into three lunar phases of ten days (Richards, 1999).

To the Hawaiians, the three phases marking the Moon's increase or decrease in size were: 1) the first appearance of the new Moon in the west in the evening; 2) the time of the full Moon when it stood directly over the Islands at midnight; and 3) the period when the Moon was waning or decreasing and showed itself in the east late at night. It was with reference to these three phases of the Moon that names were given to the nights that made up the month (Malo, 1951).

During a full Moon, the Sun and Moon are nearly opposite each other and very few minutes pass without one or the other being in our sky. During a new Moon, both bodies are in near-perfect rhythm traveling the skies together with their forces combined. Because of the interaction between the many lunar solar cycles, no two days, months or years are ever identical. There is one day each month (near the last quarter of the Moon) on which there is no moonrise. The Moon rises about 30 to 70 minutes later each day than the previous day, thus there will always be a day on which the moonrise cannot fit. The Moon rotates about its own axis in the same length of time it takes to orbit the Earth. That's what keeps the same side of the Moon always facing the Earth. (U.S. Naval Observatory, 2003.) Note also that the moonrise can occur at any time during the day or night.

The climactic seasons also comprised divisions of the yearly calendar in addition to twelve – and sometimes thirteen – months. Fishing seasons were intricately woven into the calendar as well with accompanying religious rituals. It was believed that particular religious rites made it possible to fish for a specific type of fish. It was taboo to catch fish out of the proper season (Handy et al., 1991). Scientific studies show that fish are more active for four days leading up to the full Moon and for four days after the new Moon. There are many other variables to take into consideration as well, not just the Moon phases. Things such as water temperature/color, the presence of baitfish/food items, cloud cover, bird activity, and ocean current speed/direction (Electric Blue Fishing, 2002/2003).

The information cards provided with this activity are designed to provide students with background information on the tides and the two Hawaiian seasons—kau wela the hot, dry season, and hoʻoilo the wet, cool time. Plants respond to the change in seasons with the timing of flowering and fruiting; animals respond with the timing of spawning, and in some species, with the onset of migrations. Changes in day length that occur with the change in seasons are a trigger that sets off responses in both plants and animals. Many fishes have two bones at the roof of the skull and between them is the pineal gland or "third eye." Light shining on the surface of the skin covering the gland causes the pineal gland to secrete the hormone called melatonin. During the night phase, melatonin is secreted and during daylight melatonin secretion is inhibited. In this way, an environmental cue (day length) is transformed into a physiological cue (hormone secretion). The pineal gland is also called the master clock in the lower vertebrates (fishes, amphibians, reptiles). For more information on the pineal gland, see the Virtual Creatures Website (http://summit.stanford.edu/creatures) developed by The Summit Lab at Stanford University (1997).

The spawning seasons and spawning times for each species are the result of its evolution. Throughout the life history of a species (from larvae to fry, and from juvenile to adult), it is under intense selection pressure. Until the larvae reach adulthood, they are especially vulnerable to being eaten by predators. Why a species spawns at a particular time of year, particular time of the month (lunar phases), and particular time of the day (sunset), has been forged through natural selection. The marine life forms have timed their stages of reproduction so that their young have the best chance for survival.

Teaching Suggestions

1. Write the following question on the board: ***In what ways does the Earth-Sun-Moon relationship affect life on Earth?*** Divide the class into four groups and give students a few minutes to come up with a list of responses.

2. Ask students to share their ideas and award a point for each correct item on their lists.

3. Have students help you demonstrate the annual movement of the Earth around the Sun using a lamp as the Sun and a globe as the Earth. Ask students to point out the tropics, the equator, and the Hawaiian Islands on the globe.

4. Distribute the information sheets on seasons and tides and the Hawaiian Moon calendar (one to each of the four groups). Review the Moon calendar with students. Assign the different challenges listed on the sheets and give each group of students time to prepare a way to teach the information on their respective sheets to the other groups. Let them know that they may use the globe, softball and lamp in their teaching.

5. Ask one student group to teach their classmates about the season of kau wela. Note: If students use the globe and lamp to demonstrate the seasons, suggest that they darken the classroom. Tilt the globe at about a 23 degree angle to simulate the Earth's tilt on its axis. When the globe is tilted toward the "Sun" in its orbit, this simulates summer in the northern hemisphere – when the Sun's rays shine more directly over the Tropic of Cancer and Hawaiʻi experiences kau wela.

6. Have another group demonstrate what causes the season of hoʻoilo. If students use the globe and lamp, they should keep the same tilt and walk the globe around the "Sun" to the opposite side of the Earth's "orbit" to simulate summer in the southern hemisphere, when the Sun's rays shine more directly over the Tropic of Capricorn and Hawaiʻi experiences hoʻoilo—the cool, wet season. (See diagram on page 25.)

7. Have the other two groups demonstrate the gravitational forces that create the tides. One group should demonstrate what happens when the Sun, Moon and Earth are lined up (full and new Moon – highest spring tides); and the other should demonstrate what happens when the pull of the Moon and of the Sun are at right angles (first or last quarter Moon – lowest neap tides). Note: students may need to conduct this demonstration a few times so that they grasp it.

8. Ask each group to share an example of how marine animals respond to changes in tides or seasons. Discuss other ways that living organisms respond to seasonal changes.

   <u>Discussion Questions</u>

   - What are some other examples of plant and animal responses to seasonal changes? *(Animals such as the kōlea [Pacific golden plover] and humpback whale migrate to Hawaiʻi. Plants such as mango and ʻōhiʻa ʻai [mountain apple] bear fruit in kau wela.)*

   - How do students respond to seasonal changes? *(They make changes in their selection of fishing and surfing spots and in the clothing they wear.)*

9. Read the ʻōlelo noʻeau (Hawaiian proverb) below and discuss its meaning.

   Pua ke kō, ku ka heʻe.
   (When the sugar cane tassels, the octopus season is here.)

   <u>Discussion Questions</u>

   - What does the proverb mean? *(When the sugar cane flowers, it's time to catch heʻe [octopus]. It probably refers to the month of October or ʻIkuwā, when the heʻe mauli is abundant. It lives in shallow water and is active during the daylight hours.)*

   - Do you know of other examples when plant life cycles signal a time when it's good to harvest marine species? *(See calendar cards at the end of this Unit.)*

   - Why are some of us unaware of these seasonal changes and how might this traditional knowledge be useful to us today? *(People spend less time outside and many of us spend little time fishing or growing food. This knowledge may help with gardening and fishing and raising awareness of our relationship to the land and sea.)*

10. As a homework assignment, ask students to complete the assessment activities.

Adaptations/Extensions

- Invite some fishers and/or kūpuna to visit the class and talk about their experiences with plant and animal responses to seasons and tides.
- Challenge students to write their own proverbs about seasonal changes that affect them.
- Ask a kupuna to teach the Hawaiian Moon chant to students and encourage them to practice it and teach it to younger students.

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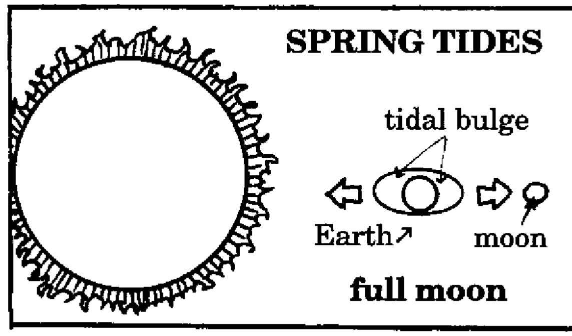
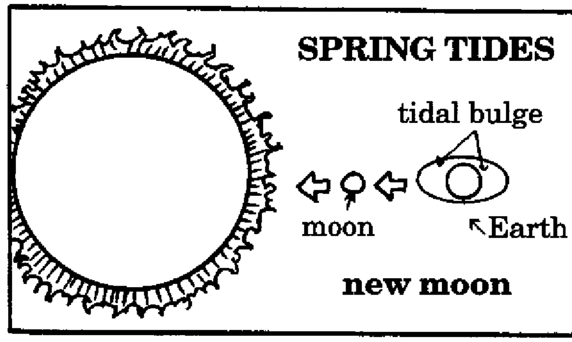
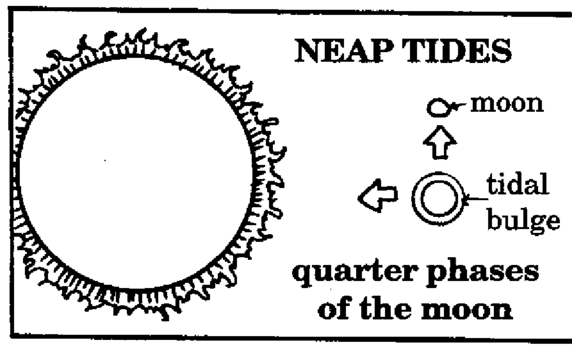
Student Information Sheet — Tides







How does the mahina (Moon) affect our lives on Earth? One of the most noticeable effects is the tides. The gravitational pull of the Moon causes a bulge in the oceans on the side nearest the Moon and on the side of the Earth away from the Moon. In the course of one day's rotation, points on the Earth will experience two high tides from the lunar bulge and two low tides. The average period between high tides is approximately 12 hours and 25 minutes. Take a look at a tide chart for Hawai'i and study the pattern of the high and low tides.

The Sun's gravitational pull also helps to create tides in the oceans, but they are much smaller and are usually masked by the lunar tides. The exception is twice during the month when the Earth, Moon and Sun are nearly in line—the times of full Moon and new Moon. During these times, the combined gravitational pull of the Sun and Moon creates higher tides known as spring tides. When the Moon is in its first or last quarter, the pull of the Moon is at right angles to the pull of the Sun so their forces interfere with each other and the tides are lower. These exceptionally low tides are referred to as neap tides.

Marine plants and animals respond to these tidal rhythms just as they respond to seasonal changes in day length and temperature. Currents resulting from the changes in tides can be quite strong in nearshore areas. In a shoreline fishpond and in the loko 'ume iki style of fishtrap, the movement of the tide through the 'auwai kai (channel) creates a current that attracts fish. When the tide is going out, fish outside the fishpond or trap swim toward the 'auwai kai. When the tide is coming in, the fish in the pond or trap swim against the current through the 'auwai kai toward the open ocean. In olden days, it was during these times that fish could most easily be scooped out of the 'auwai kai with a net. The 'auwai kai are favorite spots for fishing for the 'ama'ama (striped mullet), awa (milkfish) and the predators that lay in wait for them—the kākū (barracuda) and awa 'aua (ladyfish) and pāpio (jacks).

Student Information Sheet — Tides (continued)

Student Challenges

Group A – Spring Tides

Develop a way to teach your classmates about:

- what causes spring tides; and
- how marine life respond to spring tides. Refer to the Hawaiian Moon calendar.

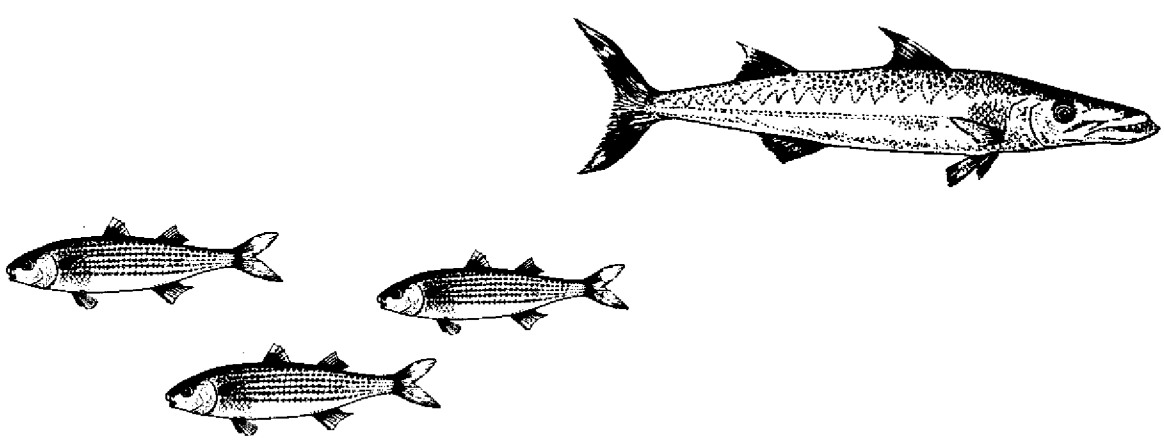
Group B – Neap Tides

Develop a way to teach your classmates about:

- what causes neap tides; and
- how marine life respond to neap tides. Refer to the Hawaiian Moon calendar.

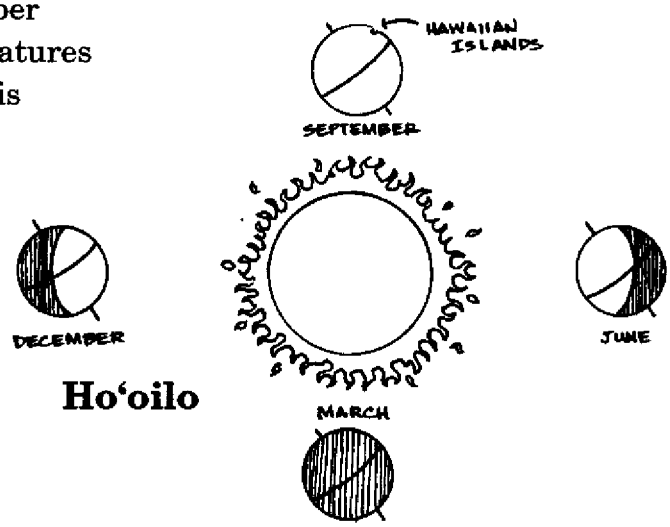
Additional information is available at the following Website:

Missouri Botanical Gardens. *Currents, Waves & Tides.* (Copyright © 2003 Missouri Botanical Gardens) <jennifer.krause@mobot.org> http://mbgnet.mobot.org/salt/motion/ (Biomes of the world, Freshwater and Marine Ecosystems)



Student Information Sheet — Hoʻoilo

Hoʻoilo is the cool, wet season from October through April. During this season, temperatures are cooler, particularly at night, and there is more rain. This is the time of year when we in Hawaiʻi usually have storms from the Kona (leeward) direction. These storms bring southerly winds and heavy rain.



The change of seasons occurs because of the Earth's annual orbit around the Sun and the tilt of the Earth's axis. The Earth makes one full rotation on its axis approximately every 24 hours, which causes night and day. The Earth's axis is tilted at a 23.5 degree angle relative to the Sun. As the Earth revolves around the Sun, the Hawaiian Islands are tilted away from the Sun during hoʻoilo.

The main Hawaiian Islands are located above the equator, south of the Tropic of Cancer where the Sun passes directly overhead twice each year, in late May and in late July. Because the Islands are not directly on the equator, there is a change in day length during the two seasons, with the shortest days occurring in December and the longest days in June.

The ʻamaʻama (striped mullet) begins spawning in December when day length is short. The adults head out to the open ocean when they are fat with sperm and eggs. The females release one to three million tiny eggs and the males release sperm. The fertilized eggs hatch about 36 hours later. In the open ocean, salinity and temperature are fairly stable and hatched larvae grow best under these conditions. What other ways have you observed marine life responding to the hoʻoilo season?

For more information about spawning seasons and related Hawaiʻi fishing regulations see the Division of Aquatic Resources Website: http://www.hawaii.gov/dlnr/dar.

Student Challenge

Group A – Hoʻoilo

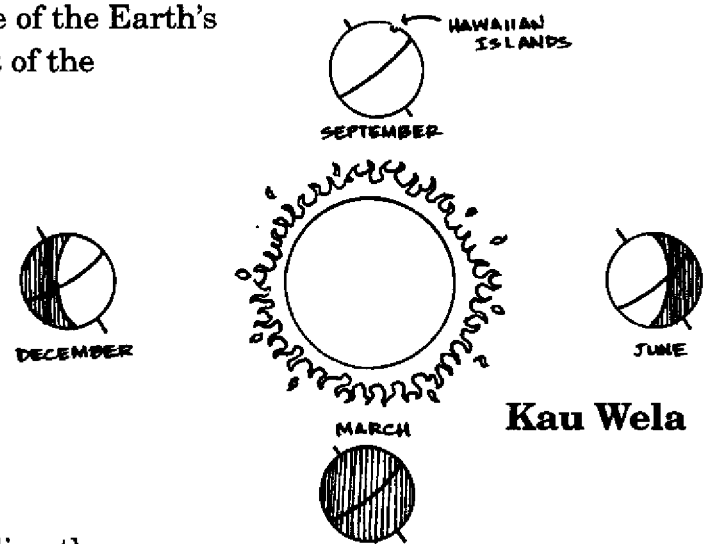
Develop a way to teach your classmates about:

- what causes hoʻoilo; and
- at least one way that marine life responds to the season. Refer to the Hawaiian Moon calendar.

Student Information Sheet — Kau Wela

The Hawaiian season of kau wela occurs from May through September. It is the hot, dry season when trade winds blow more consistently.

The change of seasons occurs because of the Earth's annual orbit around the Sun and the tilt of the Earth's axis. The Earth makes one full rotation on its axis approximately every 24 hours, which causes night and day. The Earth's axis is tilted at a 23.5 degree angle relative to the Sun. As the Earth revolves around the Sun, the Hawaiian Islands are tilted toward the Sun during kau wela.



The main Hawaiian Islands are located above the equator, south of the Tropic of Cancer where the Sun passes directly overhead twice each year, in late May and in late July. Because the Islands are not directly on the equator, there is a change in day length during the two seasons, with the shortest days occurring in December and the longest days in June.

In the summer months during the third quarter of the Moon after sunset, moi (Pacific threadfin) spawn. The timing of this spawn is tied to the survival of the eggs. During this time, zooplankton are plentiful as food for the hatched larvae, and being spawned at night, the eggs avoid most predators.

What other ways have you observed marine life responding to the kau wela season? For more information about spawning seasons and related Hawai'i fishing regulations see the Division of Aquatic Resources Website: http://www.hawaii.gov/dlnr/dar.

Student Challenge

Group B – Kau Wela

Develop a way to teach your classmates about:

- what causes kau wela; and
- at least one way that marine life responds to the season. Refer to the Hawaiian Moon calendar.

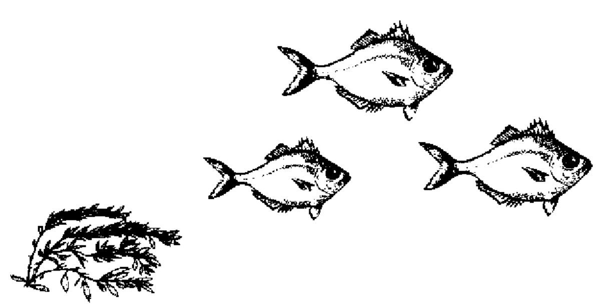
Student Activity Sheet — Fishing Tales

Name of person giving me information: ______________________________

Do you know any of the kapu seasons for fishing?

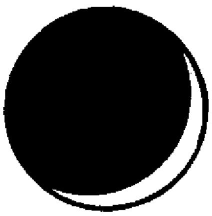
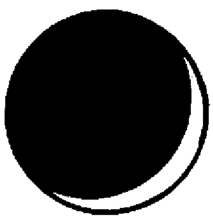
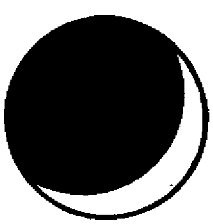
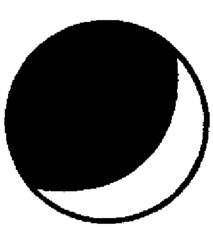
How do you use the tide in your fishing?

Have you ever used the phases of the Moon to help in fishing, diving, or other sea activities? Please explain.

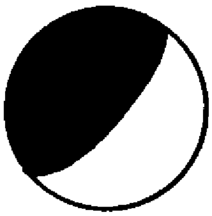
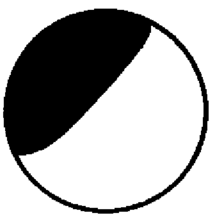
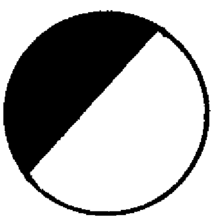
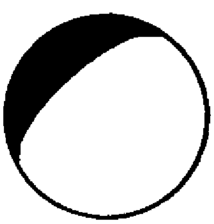
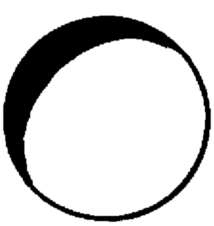
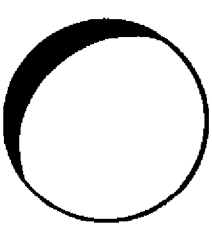


My Name:: ____________________________

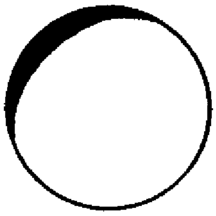
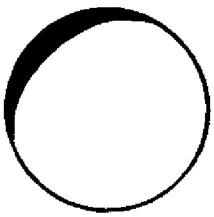
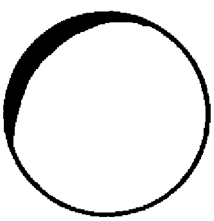
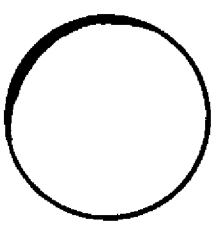
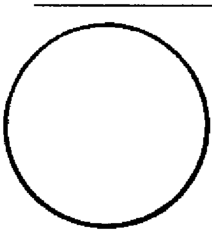
Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**1. Hilo** The moon appears as a slender or twisted sliver (hilo). Night of the new Moon, appearing in the west.	Ho'oilo Kā'elo (January – February) Kai 'ume lua – (spring tide occurs)	Tide is down in the evening and rough during the day. Beach and night fishing are good. The nehu (anchovy fish) are plentiful during this Moon. Uhu, moana, weke and kūmū are also caught. Hīnālea and maomao spawn.
	**2. Hoaka** The Moon is clear and like an arch (crescent) with points curving up on both sides like horns. The 'uhane (soul of the spirit) casts shadows.	Ho'oilo Kaulua (February – March)	Torch fishing for kūmū and manini is good on the reef. It's low tide until the morning and the night is calm. One might hear someone say "*Mai hele ma'ō e hoaka ai i ke kai o holo ka i'a*" or "Don't go over there and cast your shadow in the sea lest the fish run away." Fishermen prepare nets for catching mālolo next month. Aku is caught for ceremonial purposes in preparation for Kū Kapu.
	**3. Kū Kahi** This is the first night of Kū Kapu. The men spend this and the next three nights in worship.		Any fishing is done during the day before the Sun stands overhead. Ocean currents will soon change. Torch fishing is good on the reef. Tides are low during the day with the reefs exposed. Reef fish such as kūmū, kākū and manini can be easily caught. This and the next three nights are not good for ocean fishing.
	**4. Kū Lua** This is the second night of Kū. Men worship for four nights.		Morning fishing is good at low tide. The water is low on the reefs and the beach is crowded with fishermen before "kau i ka lolo" (the sun rests on the brains). Kākū and manini are plentiful inside the reefs.

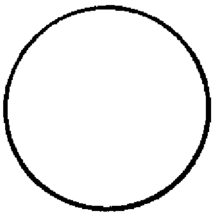
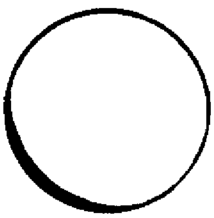
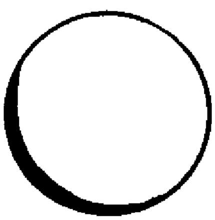
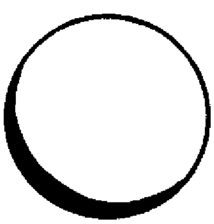
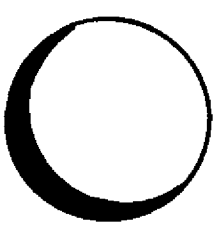
Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**5. Kū Kolu** This is the third night of Kū.	Ikuwa (October – November)	Fish are abundant during the dry season. It's low tide in the afternoon. During the Makahiki, men cannot fish in canoes. Women dive for sea urchin and gather limu and crab. ʻOʻopu, hinana, ʻōpae, and hīhīwai are gathered from freshwater streams.
	**6. Kū Pau** The last night of Kū	Kai mau mau (neap tide) begins.	It's fair fishing on the reef and low tide in the afternoon. Manini, weke, moana are caught. On this night, the fishermen say prayers for abundant fishing. Elaborate ceremonies take place in the heiau.
	**7. ʻOle Kū Kahi** The first of four nights of the ascending Moon This is an unproductive time, for ʻole means nothing.	Hoʻoilo Kāʻelo (January) Kai mau mau continues.	The tides are dangerous and high. During the wet season there are more storms, and the neap tide is almost two feet. Fishing is poor. The ʻāweoweo (bigeye fish) are plentiful. If the fisherman's wife and children do not behave, the fish will know it and run away.
	**8. ʻOle Kū Lua** Nothing will be had from the sea.	Kai mau mau ends.	Fishermen mend their gear. The room where the fishermen work on their nets is kapu to women and children.
	**9. ʻOle Kū Kolu** This is an unproductive time for ʻole means nothing.		Nets must never be walked over lest they become dirty and drive the fish away.
	**10. ʻOle Kū Pau** The last of four unproductive days		Fishermen mend gear or make nets. Women must never touch the fishermen's equipment.

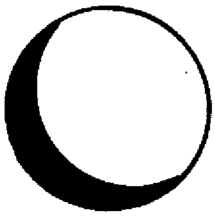
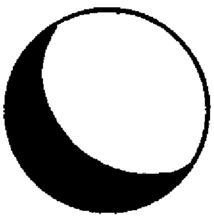
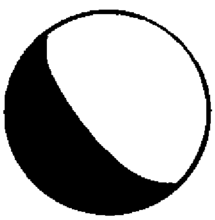
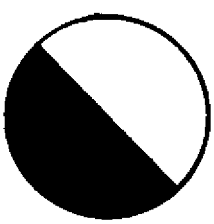
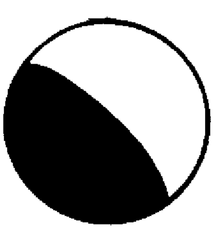
Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**11. Huna (Ho'āo)** The Moon is concealing its horns.	Ho'oilo Welehu (November – December)	The turtle comes ashore to lay her eggs during the month of Kā'elo. The tides are low. This is a good time for fishing. Fish can be found in their hiding holes. 'Ō'io spawn.
	**12. Mohalu (Mōhaluhalu)** Mohalu means clearness; the clearness of the Moon. The night is sacred to Kāne.		Good fishermen do not fish on this day. They spend this night in prayer. Fish and limu are kapu, for this night is sacred to Kāne, the life-giver. *"Mōhaluhalu ka 'ai 'ana a ka i'a"* – "The fish are opening [their mouths] to bite."
	**13. Hua** The Moon is rounded like an egg. The night brings fruitfulness.	Kai 'ume lua (spring tide) begins.	The tide goes out during the evening hours. Low tide prevails during the morning. The smart fishermen go with their canoes to do deep-sea fishing. Offerings are made to akua to increase fish (ho'oulu i'a).
	**14. Akua** The Moon has become a god (akua). It is on this night that the great round Moon becomes separated from Earth.	Kai 'ume lua continues.	Fishing is good at sea in the daytime, but the weather is changeable, and the sea might be rough or it might be calm. The night is kapu and spent in prayer. Night Marchers may be seen.
	**15. Hoku** The Moon is as bright as a star. Hoku is the fullest Moon of the month.	Kau Wela Welo (April – May) Kai 'ume lua continues.	'Upāpalu (cardinal fish) are seen at night. During the night of Hoku the tide is indefinite with high waves. The 'upāpalu come to surface in great numbers to feed. Akule, weke and moi are caught. Manini spawn.

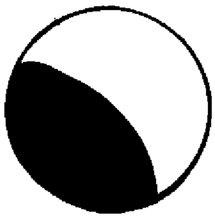
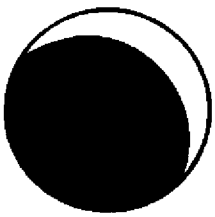
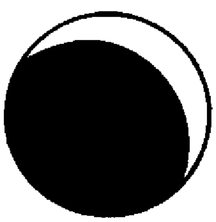
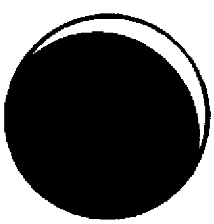
Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**16. Māhealani** An additonal night of full Moon. Symbolizes good luck and fertility.	Ho'oilo Ka'elo (January – February) Kai 'ume lua (spring tide) continues.	Lobsters come ashore. Mullet make their first run about the Islands. Ōi'o, āholehole, kala (at their best) and uouoa (false mullet) are plentiful. If the head of the uouoa is eaten, sleeplessness and nightmares can occur.
	**17. Kū Lua** This is the second night after the full Moon. The Moon sets after sunrise.	Kai 'ume lua continues.	A high tide of the evening hours recedes during the night. The incoming tide gathers up the sand and restores it to the beaches bringing with the sand much limu.
	**18. Lā'au Kūkahi** Lā'au days favor growth in plants and trees; also a good time to use medicine. The first of three lā'au days	Kau Wela Ikiiki (May – June) Kai 'ume lua ends.	Ailing fishermen might go to the kauka lapa'au (doctor) to be healed. If the fisherman leaves bait at home, no one can eat it, no matter how hungry they are.
	**19. Lā'au Kūlua** The second lā'au night	Ho'oilo Welo (April – May)	Fishing is fair. Fishing is best at sea. Fishing gear is stored in high places in the hale to keep it from being soiled by children and animals. Fishermen prepare their nets for catching 'ōpelu.
	**20. Lā'au Pau** Lā'au nights are finished.	Kau Wela Ikiiki (May – June)	Seas become rough. This is the last day to take advantage of using medicines for healing. 'Ōpelu start to run.

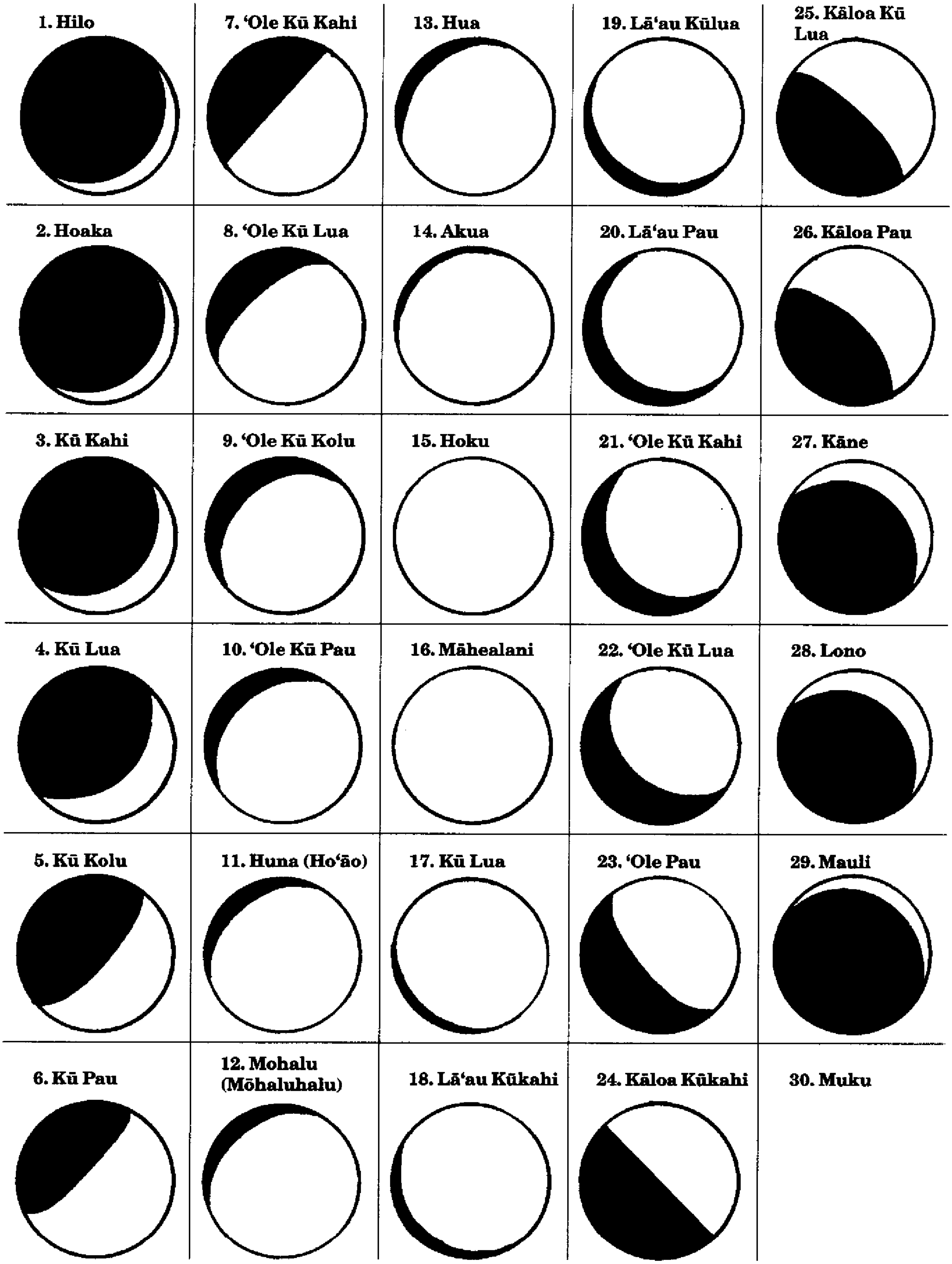
Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**21. ʻOle Kū Kahi** This is the first of three nights of the descending Moon.		The three days of ʻOle are a signal for rough seas and poor fishing.
	**22. ʻOle Kū Lua** The second night of the descending Moon	Hoʻoilo Welehu – Kāʻelo (December – January)	ʻOle is the name of the wind that blows during the phases of the first quarter and third quarter.
	**23. ʻOle Pau** ʻOle nights are finished.		When the fisherman went fishing, no one was allowed to ask him where he was going, and he would never say he was going fishing. Hawaiians believed that the fish have ears and can overhear conversations.
	**24. Kāloa Kūkahi** First night of Kāloa Kapu for the deity Kanaloa	Kau Wela Mahoe Mua (August – September) Kai mau mau (neap tide) begins.	The seas are still rough. The women can gather limpets and limu. Women go fishing along the shore using their hands (hahamau). They feel along rocky ledges and boulders and coral reefs where the surf breaks. They seize wrasse, cowries, ʻopihi, and heʻepali (small rock octopus).
	**25. Kāloa Kū Lua** Second night of Kāloa Kapu	Kai mau mau continues.	The seas begin to calm and fishing is good on the reefs and at sea. The women gather shellfish and limu and wade into the tidal waters and catch fish with their hands or baskets.

Hawaiian Moon Calendar

Moon Phases	Name and Translation	Seasons and Tides	Fish Response to Tides
	**26. Kāloa Pau** The night of Kanaloa ends.	Kai mau mau ends.	A good day for reef fishing and hunting for shellfish. Good time to gather limu.
	**27. Kāne** Deity of all living things; the night is kapu to Kāne. No fires can be made. Sound is forbidden.		No fishing is allowed. Families who have sharks as ʻaumakua might choose this day to transfigure their recently deceased relative into sharks. Night Marchers may be seen. The Moon rises at the dawn of day.
	**28. Lono** Deity of fertility The night is kapu to Lono. No noises can be made at all.		Excellent day and night for pole fishing, diving, and torching. Fishermen pray for good fishing and good spawning of fish. If weke pueo are eaten at night, nightmares can occur. If the fish are caught near Lānaʻi, the nightmares are worse.
	**29. Mauli** The last breath The feeble Moon rises a little before sunrise and is seen for the last time.		Good day for reef fishing. Good night for ulua fishing. In the afternoon the fishermen set sail, arriving at the fishing ground in the evening. Mālolo and lobster are used for bait.
	30. Muku Finished or dying, cut short The utterly dark night has no Moon at all.		Good day for fishing offshore and on the reefs. The tide brings back the sand to the beaches. At night, weke, kūmū, moana, and many other reef fishes can be caught easily by spear because they are sleeping.

Hawaiian Moon Phases

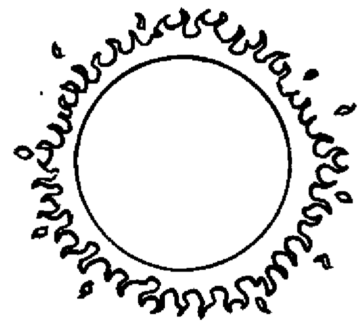


Kai Moku:

The Turn of the Tide

- How do the tides affect the growth of phytoplankton and the level of dissolved oxygen in a fishpond?
- What other factors affect the growth of phytoplankton?

Hawai'i DOE Content Standards



Science: Doing Scientific Inquiry
- Students develop questions and hypotheses that can be answered through scientific investigations.

Science: Cycle of Matter and Energy Flow
- Explain how plants use the energy from sunlight and matter from the atmosphere to make food.

Grades 6 – 8 Performance Indicators

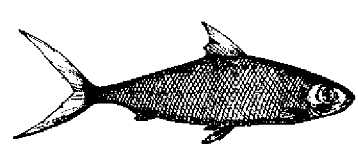
- Develop hypotheses that can be answered through investigations.
- Describe clearly a plan to answer the question or test the hypothesis.
- Collect and organize accurate data and interpret data to explain clearly what the data suggests or infers.
- Draw logical conclusions and explanations showing the link between evidence and results of the investigation.
- Summarize major findings and connect them with the "real world."
  Reflect on new evidence from other valid sources and revise conclusion and explanation as needed. Include recommendations for improving the investigation.
- Explain how all living things use food energy and matter from the atmosphere to provide energy for life.
- Explain the cycle of matter and energy in photosynthesis and respiration.

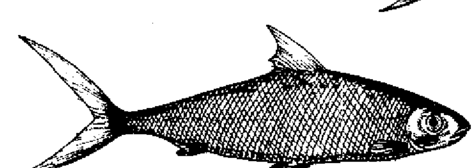
Key Concepts

- Phytoplankton uses energy from the sun and nutrients from fish wastes to make food.
- Tidal circulation helps prevent accumulation of wastes that leads to stagnation and loss of the dissolved oxygen needed by fish.

Suggested Prerequisites

activities on photosynthesis and food chains





Activity at a Glance

Students develop hypotheses about how the tides affect the growth of phytoplankton and levels of dissolved oxygen in a fishpond and then conduct experiments to test their hypotheses.

Skills

predicting, reasoning, measuring, recording, writing

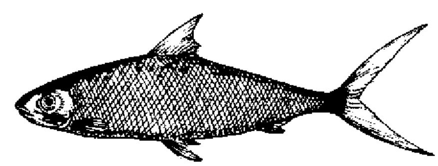
Assessment

Students:

- Write a scientific report describing the hypothesis, prediction, methodology and results.
- Diagram how phytoplankton uses energy from the sun and nutrients from fish wastes to make food.

Time

2 class periods plus partial class periods for 7 - 10 days

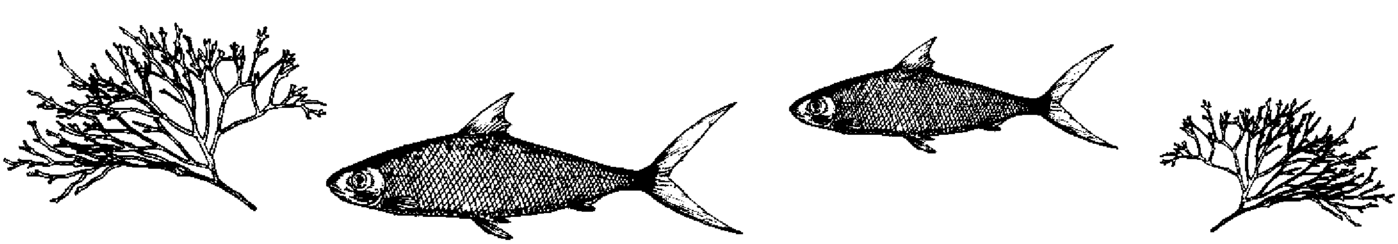


Skills

hypothesizing, analyzing, writing

Vocabulary

phytoplankton – the tiny plant organisms in plankton
dissolved oxygen – molecules of atmospheric oxygen near the water surface that become mixed in and stay dissolved among the water molecules, expresed in milligrams per liter (mg/l) or parts per million (ppm)
nutrient – any matter that, taken into a living organism serves to sustain it, promote growth, replace loss, and provide energy
hypothesis – assumption or guess
stagnation – to become stale or foul from standing, as a pool of water
scientific method – a process to generate new knowledge that involves asking a question, stating a hypothesis, planning and conducting an investigation to test the hypothesis, gathering data, analyzing data, communicating findings, and defending or revising conclusions based on evidence
zooplankton – the tiny animal organisms in plankton
photosynthesis – the production of carbohydrates using sunlight energy to combine carbon dioxide and water in the presence of chlorophyll
siltation – to become filled or choked with silt
decomposition – the process of organic and inorganic materials being broken down into smaller fragments or simpler compounds
silt – earthy matter or fine sand carried by moving or running water and deposited as sediment



Materials

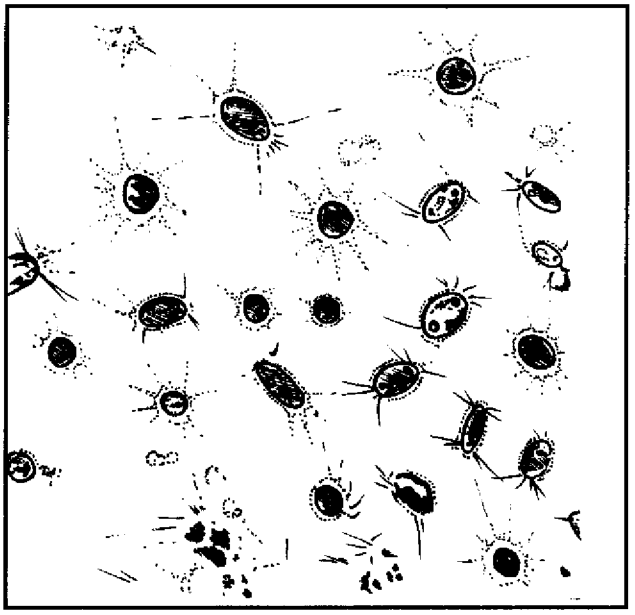
Provided:
- student data sheet
- vocabulary cards

Needed:
- 2 10-gal. aquaria or any large clear containers (see Advance Preparation)
- 20 - 30 guppies
- fish food
- small fish net for use in aquaria
- pitcher (for pouring water)
- water test kit for dissolved oxygen
- water hardness test kit (optional: available from pet stores)
- microscopes (optional)

Advance Preparation

Place the two aquaria near a window and fill them with fresh water up to the half-way point. Add half of the guppies to each tank. Optional: collect some rainwater for students to compare with tap water in a test of water hardness (mineral content). Note: water hardness, or the amount of calcium carbonate ($CaCO_3$) in tap water, ranges between 80 and 120 ppm (parts per million) and rainwater contains around 10 to 20 ppm ($CaCO_3$). Test kits for dissolved oxygen and hardness are available from a variety of sources including LaMotte (www.lamotte.com/) and Hach (www.hach.com/); for additional information see Resources in the Appendices.

What to expect: If the aquaria are placed where there is ample sunlight (near a window) and the fish are fed on a daily basis with fish food (but not overfed, where leftover food remains on the bottom of the aquaria), in a few days the water in the aquarium that is not replenished by "tides" will begin to get cloudy and murky. After a week to ten days, the water will start to turn green. Small microscopic algal cells (phytoplankton) have begun to grow in response to the nutrients (fertilizer) in the water as a result of the food that has been fed to the fish. Fish food is being used to make the fish grow, and in the process, waste products (feces and urine) serve as fertilizer to the phytoplankton. In the fish tank with the water replenished by "tides," the build-up of phytoplankton will be prevented by the replenishment of water twice per day. Note: the individual phytoplankton cells can only be seen under a compound microscope at high magnification.



phytoplankton (magnified)

Background

The shallow depth (two to three feet) of Hawaiian fishponds provides the optimal light conditions for plankton and limu growth. Natural fertilizers such as nitrogen, come from marine animal wastes in the pond. Minerals such as phosphate and calcium, come from incoming streams, and to a lesser degree from the tides, which also contribute salt (NaCl, or sodium and chloride). The fishpond mākāhā (sluice grate) and pond walls were designed to allow water circulation from the tides. They help control water circulation and prevent stagnation and the build-up of sediments, which is critical to maintaining a healthy, balanced fishpond ecosystem.

Natural Fertilizers

Limu and microscopic plankton provide food for the fish grown in the pond—the ʻamaʻama (striped mullet) and awa (milkfish). The kiaʻi loko (fishpond caretaker) guarded and cared for the pond, just as a farmer tends his pastures for cattle. In addition to the nutrients that occur naturally in the pond, the kiaʻi sometimes "fertilized" the pond by adding additional food for fish, such as kalo (taro), ʻulu (breadfruit), uala (sweet potato), and mussels and stones with limu.


kiaʻi loko (fishpond caretaker)

Fishpond Maintenance

To maintain the pond, the kiaʻi loko kept the pond walls intact and checked for excessive limu growth and build-up of pond sediments. If the mats of limu in the pond grew too thick, the limu was thinned by hand. This helped to prevent the depletion of dissolved oxygen in the pond which occurs when large amounts of limu decays. And when the bottom sediments of soil and decayed organic matter got too thick, the commoners were called upon to help clear this layer of sediment. The sediments were stirred up and the pond was flushed as the incoming tide circulated in the pond through the mākāhā and the outgoing tide washed some of the sediment out to sea. Another way of preventing siltation may have been to divert some of the stream water that carries heavy loads of sediments down to the pond during the rainy season. To avoid pollution from human wastes and to protect water quality, Hawaiians located their homes away from the fishponds. These practices helped to prevent stagnation and maintain the level of dissolved oxygen needed by fish.

The ancient ʻauwai kai with mākāhā did not have the movable water gates that appeared at the turn of the twentieth century. So the location of the different mākāhā in the early ponds was critical to water circulation. In the early 1900s, the Chinese and Japanese introduced movable water gates on the ocean side of the mākāhā that allowed them to cut down the rate of water exchange and manipulate the phytoplankton density by closing the gates. As with an aquarium of guppies that lacks filtration, the water in the fishponds will begin to turn green after a few days, when the phytoplankton grow due to the build-up of nutrients (excrement/fertilizer).

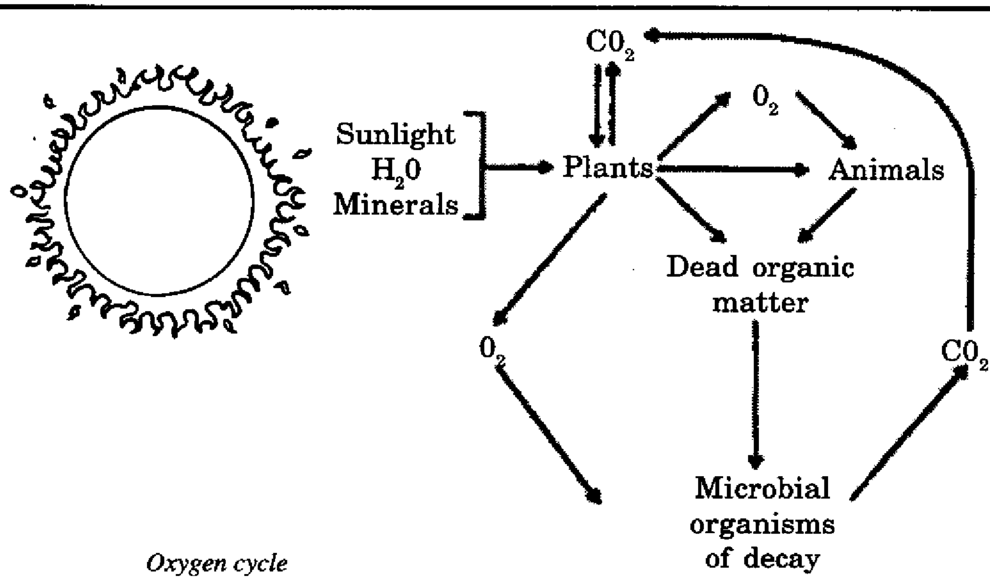
Some Factors Affecting Fishpond Productivity

- *water depth*: ponds 2 to 3 feet deep allow sunlight penetration that favors the growth of phytoplankton, zooplankton and limu.

- *salinity*: The salinity (amount of mineral salts dissolved in the water) fluctuates with tides, depth, and proximity to freshwater streams and springs. Apple and Kikuchi (1975) reported a range of salinity in fishponds they studied to be from 2 to 32 ppt (parts per thousand).

- *circulation*: water circulates with the incoming tide to wash sediments out to sea and prevent stagnation and accumulation of bottom sediments. Bottom sediments are composed of silt and a layer of decomposing organic matter—partly digested limu eaten by fish and other animals. These sediments appear as black mud that smells like rotten eggs since these decomposing sediments take dissolved oxygen out of the water and produce hydrogen sulfide. In areas of the pond with this decomposing layer, Apple and Kikuchi (1975) report that if the hydrogen sulfide rises above 3 ppm (parts per million) it is considered injurious to young fish.

- *dissolved oxygen*: Apple and Kikuchi (1975) tested dissolved oxygen levels in 18 fishponds and found a range from 6 to 13 ppm. The mean level of 7.9 ppm indicated high levels of photosynthetic activity in the ponds. Like temperature, the level of dissolved oxygen will vary throughout the day with changes in temperature, light and cloud cover. When there are excess nutrients and the phytoplankton concentration is high, a potentially lethal situation can occur, especially during the night, when there is no sunlight and no wind or circulation. During the evening the phytoplankton that were making oxygen during the day stop as the photosynthetic "machinery" shuts down. Because the phytoplankton are also alive and need oxygen to live, they begin to take up oxygen along with the other living organisms in the pond. And if the phytoplankton level becomes too high and there is a large amount of fish, there will be almost no oxygen left in the water. This causes the fish to come to the surface of the water to breathe or gasp for air. Usually, in Hawai'i, we are blessed with the trade winds, but during times of Kona winds, when there is almost no breeze and the water is still, catastrophic overnight fish kills in fishponds have been recorded due to the lack of oxygen in the water.



Oxygen cycle

- *turbidity* (water clarity): the clarity of the water is related to the presence of mineral or organic particles suspended in water. Clear water allows sunlight to penetrate to the bottom and warm the cooler water. Cloudy water as a result of high turbidity reduces this sunlight and may reduce the growth rate of the limu, phytoplankton and fish.

- *pH:* the pH, (degree of alkalinity or acidity) of the water is measured on a scale of 1 to 14, with 1 being most acidic, and 14 being most alkaline. Due to the presence of minerals in Hawaiian waters, the pH of brackish water fishponds is generally alkaline (8.0 – 9.0).

- *water temperature:* the temperature varies seasonally and throughout the day. In a healthy pond, the temperature is relatively even in the water column and ranges from 64 to 88 degrees Fahrenheit.

- *nutrient composition*: the nutrients from the wastes of aquatic organisms provide natural fertilizer for the phytoplankton and limu. If too many nutrients are added (chemical fertilizers or pollutants) algal blooms may form. These blooms can decrease clarity and light penetration, which causes limu to die. As the limu decompose, dissolved oxygen is depleted. Decreased dissolved oxygen then adversely affects the fish population. However, if algal blooms are rich in diatoms they can enhance the natural productivity of the pond. The diatoms in these blooms are nutritious and allow sunlight to warm the lower water layer and enhance natural productivity. According to Carol Wyban (1992), "Chinese aquaculturists manage their water quality by color. Diatom-rich waters are a golden-brown color."

Teaching Suggestions

1. Gather students around the aquaria and ask them to imagine that these are fishponds. Discuss what makes the fishpond work.

   Discussion Questions

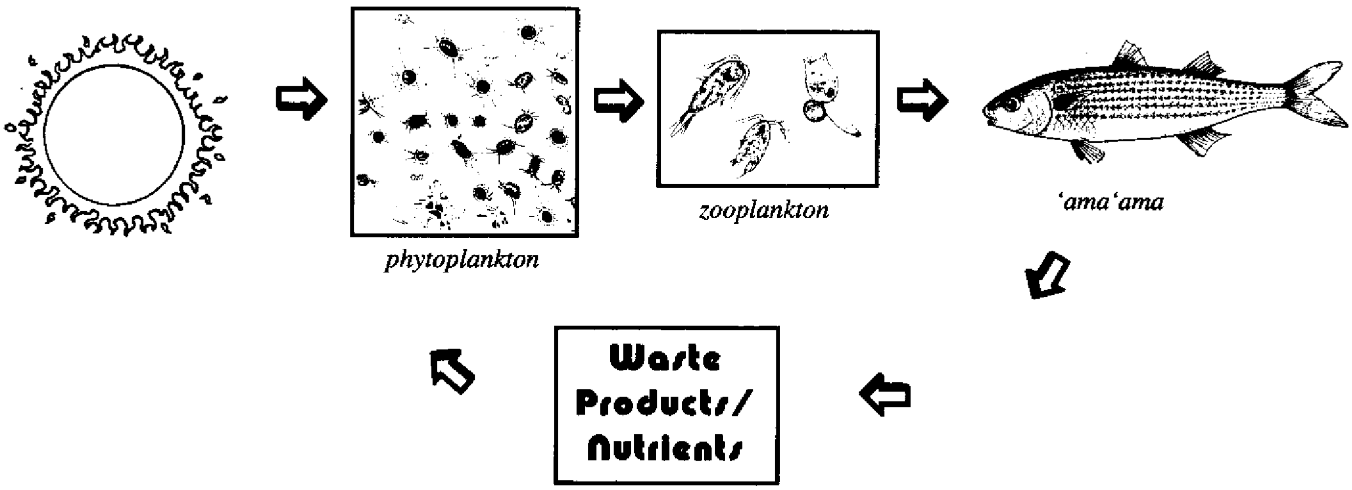
   - If the guppies represent the ‘ama‘ama or the awa, what conditions do they need for survival?
     (food—limu and plankton, and oxygen)

   - What environmental conditions do limu and plankton need in order to grow? *(sunlight, water, nutrients – review the process of photosynthesis.)*

   - Where do the nutrients come from?
     (*decay of dead plants and animals in the pond, and animal wastes and minerals washed in from streams and tides*)

2. To reinforce students' knowledge of the scientific terms, distribute the vocabulary cards and have them play a matching game. Give half of the class cards with just the terms on them and the other half of the class the definitions. Challenge students to find the classmate that has the matching card. Then have pairs of students share the terms and definitions with their classmates.

3. Review the basic fishpond food chain and nutrient cycling by drawing a diagram on the board.



4. Diagram the cycle of oxygen in the pond (see diagram in Background). Ask students to predict when the oxygen level would be highest in the pond and explain their ideas.

5. Explain that your classroom "fishponds" are going to be in a race to see which one grows the most phytoplankton and which has the most dissolved oxygen. For one week, pond 1 will have "tides." Pond 2 will be the control and will have no tides. Twice each day, the tide will turn. To simulate this, students will remove one-third of the water from pond 1 (low tide) and then add the same amount of clean water (high tide). Both ponds will receive the same amount of fish food twice per day (about 1/8 tsp.).

6. Ask students to cast written votes for the pond that they believe will grow the most phytoplankton and have the most dissolved oxygen. Collect their ballots and tally their votes.

7. Distribute the student data sheets and ask students to write up the research question, the variables, the method, and their hypotheses. Review students' responses and discuss carrying out the method. Assign different groups of students to care for the ponds during each day of the experiment.

8. All students should record the amount of nutrients added each day, test the dissolved oxygen levels, and make written notes of their daily observations of the "ponds."

9. At the end of the experiment period (7 - 10 days), have students decide which pond is greener (indicating the level of phytoplankton build-up). If microscopes are available, view the phytoplankton under high magnification.

10. Have students take a final measurement of the level of dissolved oxygen in the "ponds." Declare the winning pond.

11. Ask each student to complete the assessment activity and conduct a class discussion.

Discussion Questions

- What appear to be the most important environmental conditions for growing phytoplankton?
(sunlight, nutrients)
- Which pond has a higher level of dissolved oxygen? Why?
(The pond with "tides" may have more dissolved oxygen since there is less phytoplankton buildup and decomposition, which uses up oxygen.)
- What are the shortcomings of this experiment in actually simulating the tides in a fishpond?
(The water in the experiment is tap water and does not contain the minerals in seawater. The tank doesn't have the rock walls or mākāhā of a fishpond and water is removed from the experiment instead of flowing, mixing and recirculating as it does in the pond.)
- What can you apply from this experiment to the question of how the tides in the fishpond affect the growth of phytoplankton and the level of dissolved oxygen in the pond?
- How does the amount of phytoplankton in a pond relate to the amount of fish that can be raised?
(In a healthy pond where sunlight penetrates to the bottom and where the water is circulating with the tides, there is sufficient phytoplankton for fish, but not so much that the water becomes stagnant.)
- What's the critical missing link in our simplified "pond" food chain?
(*Zooplankton such as rotifers or daphnia will eat the phytoplankton and help to control their growth.*)
- How did the early Hawaiians design their ponds to promote the best conditions for limu and fish growth?
(*mākāhā for circulation of water; stream inputs)*

Adaptations/Extensions

- Add rotifers or daphnia (zooplankton) to the "ponds" and see how long it takes for the water to become clear again. View the zooplankton under a microscope and have students sketch them.
- Have students conduct research to learn more about cultural uses of limu (seaweed). Hawaiians identified more than 60 kinds of limu that were edible. Limu pahe'e (slippery) is seasonal; it appears in winter on rocks in areas of heavy surf where fresh water mixes with the sea. During drier months, it takes a microscopic form and is not visible. This rare limu was reserved for ali'i and kapu to commoners. Today related species of seaweed are cultivated in northern Asia and packaged as nori. See the pond life cards in the Appendices for some additional information on limu.

Reference

Apple, Russell A. and William K. Kikuchi. 1975. *Ancient Hawaii Shore Zone Fishponds: An Evaluation of Survivors for Historic Preservation*. National Parks Service, U.S. Department of the Interior. Washington, D.C.

Student Data Sheet

Name____________________________

Research Question: What are we trying to find out?

phytoplankton magnified 1000x

Variables: What things might affect the growth rate of phytoplankton? What might affect the level of dissolved oxygen?

Hypothesis: What do we think is the answer to our research question?

Method: How will we test our hypothesis?

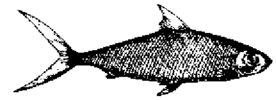
Observations: Record your daily observations on the other side of this page. Be sure to note anything that is added to your "ponds" and the exact amount added.

Conclusion: What did you learn? Write up the results of this experiment on a separate piece of paper. Explain how the phytoplankton grew and any differences in the two "ponds."

Student Data Sheet (continued)

Name ______________________

Date	Observations



Vocabulary Cards (front)

phytoplankton	zooplankton
nutrients	photosynthesis
dissolved oxygen	hypothesis
stagnation	siltation
decomposition	scientific method

Vocabulary Cards (back)

the tiny animal organisms in plankton

the tiny plant organisms in plankton

the production of carbohydrates using sunlight energy to combine carbon dioxide and water in the presence of chlorophyll

any matter that, taken into a living organism, sustains it, promotes growth, replaces loss and provides energy

assumption or guess

oxygen dissolved in water

to become filled or choked with silt

to become stale or foul from standing, as a pool of water

a process to generate new knowledge that involves asking a question, stating a hypothesis, planning and conducting an investigation to test the hypothesis, gathering data, analyzing data, communicating findings, and defending or revising conclusions based on evidence

the process of organic and inorganic materials being broken down into smaller fragments or simpler compounds

The Hawaiian Calendar

It can sometimes become quite confusing to understand the traditional Hawaiian view of what we call a calendar. The most obvious example of this is the celebration of the New Year, the Makahiki. The beginning of the year is celebrated in a different month on each of the four major islands. This is because a separate calendar was kept for each island. This included lunar, solar, and star calendars. The New Year, Makahiki, began anywhere from October to January, depending on the various island systems used. This happens approximately on November 20 in our current era, in the month of Makali'i. One thousand years ago this event would have occurred in October and even as early as September (Magic Island Calendar, 1998).

Since the Hawaiians did not develop a written version of their language until the 1830s, the tracking of time and all other events was done from memory through a tradition of prayers and chants that were passed orally from generation to generation. A system of stone markers was used on the island of Hawai'i which designated the positions of the sun during the year. Stones were "used to track the sun's limits north and south in order to mark the seasons in addition to use of the seasonal migrations of the plover on their course north and south during the year" (Richards, 1999).

Sources:

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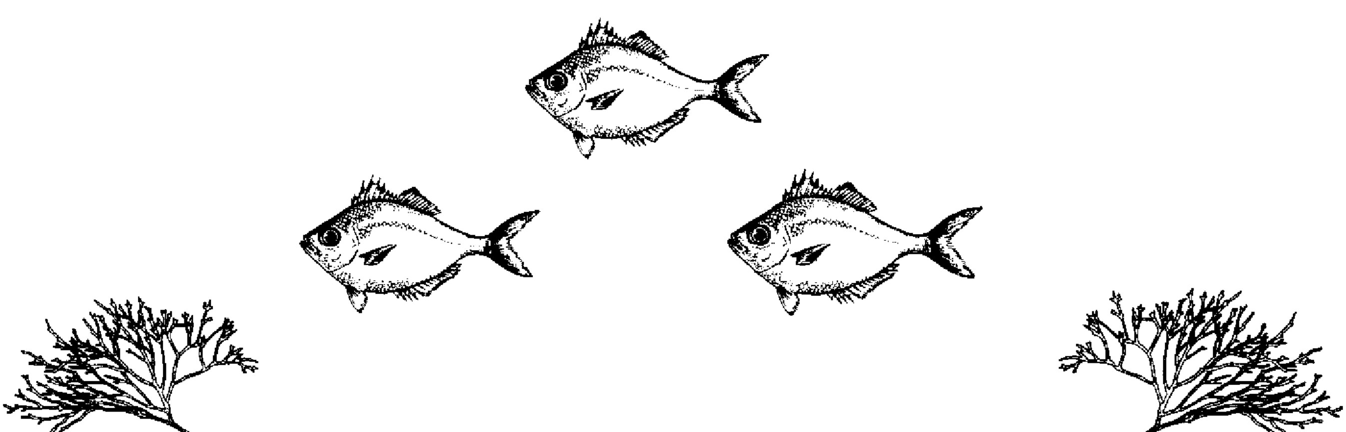
The Magic Island Calendar. *Traditional Hawaiian Calendar*. (Copyright © 1998 Magic Island Internet Systems) <mgis@aloha.net> http://www.magicmoku.com/calendar/traditional.html



Hawaiian Names for Months by Island

Month	Hawai'i	Moloka'i	O'ahu	Kaua'i	Maui
November	Welehu	Hilina Mā	Kā'elo	Hilina Mā	'Ikuwā
December	Makali'i	Welehu	Kaulua	Hilina Ehu	Welehu
January	Kā'elo	'Ikuwā	Nana	Hilioloho	Makali'i
February	Kaulua	Hinaia'ele'ele	Welo	Hilionalu	Kā'elo
March	Nana	Welo	Ikiiki	Hulipau	Kaulua
April	Welo	Makali'i	Ka'aōna	'Ikuwā	Nana
May	Ikiiki	Kā'elo	Hinaia'ele'ele	Welehu	Welo
June	Ka'aōna	Kaulua	Māhoe Mua	Kā'elo	Ikiiki
July	Hinaia'ele'ele	Nana	Māhoe Hope	Ikiiki	Ka'aōna
August	Māhoe Mua	Ikiiki	'Ikuwā	Hinaia'ele'ele	Hinaia'ele'ele
September	Māhoe Hope	Ka'aōna	Welehu	Māhoe Mua	Hilin Ehu
October	'Ikuwā	Hilina Mā	Makali'i	Māhoe Hope	Hilina Mā

Source: Malo, David. 1951. *Hawaiian Antiquities.* Bernice P. Bishop Museum, Spec. Pub. 2, Second Edition, Bishop Museum. Honolulu, HI.

Kāʻelo / January

O Kāʻelo ka malama, pulu ke aho a ka lawaiʻa.
(January is the month when the fisherman's lines are wet.)

This is a good time for fishing for bottom fish like ʻōpakapaka (pink snapper) and nearer shore fishing is good for ʻōʻio (bonefish) and ulua (trevally). It's also a time to look for the constellation of Orion, which is now visible in the eastern evening sky.

Puleileho ke kai o Kāʻelo.
(A rough sea in the month of January.)

Limu kala washes ashore in the heavy surf during this time of year and it can be gathered along the beach. Fish are drawn to the limu so this can be a good time to fish.

Conservation Notes:

Kaulua / February

Pōhai ka manu maluna, he iʻa ko lolo.
(When the birds circle above, there are fish below.)

This is the time when the four-month Makahiki season came to a close in old Hawaiʻi. At this time, the kapu began for catching ʻōpelu (mackerel scad), and the kapu on catching aku (bonito) was lifted. Hawaiians located schools of aku by watching where the seabirds like the noio (Hawaiian noddy tern) would gather. They lured the fish with nehu (native anchovy).

Conservation Notes:

Calendar Cards

Nana / March

O Nana ka mālama; momona ka pāpaʻi.
(March is the month; the crabs are fat.)

During this time female crabs are carrying eggs on the underside of their abdomens. If you catch a crab carrying her eggs, be sure to carefully release her so that the eggs can hatch and the young can grow. Pua ʻama ʻama (baby mullet) begin showing up along the shores of estuaries during this time. Look for schools with hundreds or thousands of these tiny fish near shore. This is a good time to stock fishponds with ʻamaʻama. This is also the time when the kapu on catching ʻamaʻama was lifted in old Hawaiʻi.

This is the time of an equinox—the sun rises due east and sets due west.

Conservation Notes:

Welo / April

Ka iʻa hoʻāla i ka pō, wai lama i ke ahi.
(The fish that wakes people up at night and causes a glowing of torches over the water.)

Swarms of mālolo (flying fish) appear at this time of year. Look for them skimming the surface of the water and watch for the lights of the fishers at night. This is the month when the moi (Pacific threadfin) begins to spawn, usually during the third quarter of the moon. This is the peak nesting season for ʻalae keʻokeʻo (Hawaiian coot). Native coots build a floating nest platform near the edge of a pond. These endangered birds lay five to six eggs in a nest cup several inches above water level.

The constellation Leo is in the eastern sky in the evening.

Conservation Notes:

Ikiiki / May

Ka iʻa hoʻopā ʻili kanaka o Waimea.
(The fish of Waimea that touch the skins of people.)

Young ʻoʻopu nākea (hinana) move from the sea up into streams usually between December and July. At Waimea on Kauaʻi, there were so many hinana at this time that one couldn't go into the water without rubbing against the fish. Naiʻa (spinner dolphins) remain near shore at this time since food is plentiful. These naiʻa were ʻaumakua (personal gods) for some families. If a person jumped to conclusions, another might say, "He naiʻa, he iʻa lele!" (It is a dolphin, a leaping fish!)

The star Hōkūleʻa (Arcturus) is visible in the east-northeast evening sky.

Conservation Notes:

Kaʻaōna / June

Ola aku la ka ʻāina kaha, ua pua ka lehua i kai.
(Life has come to the kaha lands, for the lehua blooms are seen at sea.)

This is the time when ʻōhiʻa lehua trees blooming on shore were visible from canoes off Kekaha on the Kona coast of the island of Hawaiʻi. This was the time of deep-sea fishing for aku (bonito or skipjack tuna), which Hawaiians called "pua ka lehua" (flowers of the lehua). They didn't want to call the aku by name since this might scare the fish away.

Hua ka ʻulu ku mai ka heʻe.
(When the breadfruit is ripe, the squid comes in.)

ʻUlu (breadfruit) bears fruit most heavily at this time of the year. This is a reminder that (heʻe) squid are abundant now too. The orange-backed flying squid is more plentiful at this time and fishers would have been able to catch it where there are sudden drop-offs to deeper waters.

Conservation Notes:

Calendar Cards

Hinaia‘ele‘ele /July

Pala ka hala, momona ka hā‘uke‘uke.
(When the pandanus fruit ripens, the sea urchin is fat.)

When the orange fruit of the hala tree is ripe, sea urchins are fat with eggs. This type of sea urchin has blunt, short spines and lives on rocks in inshore waters. The ripe hala fruit is also a cue to search for uhu (parrot fish) that feed on the sea urchins. If you catch an uhu under 14 inches long, let it go so it can grow to reproduce. Pua awa (milkfish fry) begin showing up near shore in sheltered areas at this time of year. This is a primary time to stock fishponds with awa. Pua ‘ō‘io, (bonefish fry) make their appearance at the same time as the milkfish fry and are very similar in appearance. Both fish are prized for food.

Look for Manaiakalani (Māui's fishhook or Scorpio) in the southeast evening sky.

Conservation Notes:

Māhoe Mua /August

Ehuehu kai, oho ka moi.
(Where the sea broils, there the moi fish dwell.)

Large schools of juvenile fish including halalū (akule), moi li‘i (immature moi or Pacific threadfin), ‘oama (young weke or yellowstripe goatfish) move close to shore to sheltered bays and coves at this time of year. Fishers go out with nets and poles both day and night to catch these fish. If you catch these fish be sure observe the minimum catch sizes.

Pupuhi ka he‘e o kai uli.
(The octopus of the deep spews its ink [into the water]).

This proverb refers to a person who goes off in secret. The octopus uses an ink-like substance to hide and escape from its enemies. This is a good time to catch he‘e (octopus) with lures.

Look for the constellation Leo in the western evening sky.

Conservation Notes:

Māhoe Hope / September

Lawelawe ke ō! Lawelawe ke ō!
(Take the food! Take the food!)

The whistle call of the kioea (bristle-thighed curlew) was said to urge fishers to launch their canoes to go to sea and "take the food." Kioea migrate to Hawai'i at this time of year and can be found along the shore. Also look for the 'ūlili (wandering tattler) that migrates to Hawai'i now for the winter. Watch for this gray bird with yellow legs along the shore or on rocks in streams searching for food. In old Hawai'i, the kapu for catching 'ōpelu (mackerel scad) was lifted this month.

This is an equinox time when the sun rises due east and sets due west.

Conservation Notes:

'Ikuwā / October

'Ōpelu ha'alili i ke kai.
('Ōpelu that make the sea ripple.)

This old Hawaiian saying about 'ōpelu (mackerel scad) refers to energetic people. These fish are plentiful now, swimming in schools near the surface of coastal waters. The traditional way to catch 'ōpelu is to lure them with kalo (taro) into a funnel-shaped net. It's also a good time to catch moi (Pacific threadfin).

Look for the constellation Makali'i (Pleiades) to appear in the east-northeast sky after sunset around the middle of this month. This marks the beginning of Makahiki—a four-month long harvest festival, dedicated to Lono, a Hawaiian god of rain and agriculture. Kapu begins for aku (bonito or skipjack tuna) to allow these fish to reproduce and their populations to grow.

Conservation Notes:

Calendar Cards

Welehu / November

Ka iʻa a ka wai nui i lawe mai ai.
(The fish borne along by the flood.)

At this time of year, ʻoʻopu nākea (goby fish) come downstream to spawn in heavy rain. Hawaiians diverted streams to bring ʻoʻopu into their upland fishponds. Āholehole fish move to stream mouths at this time of the year to catch the larva of animals like the ʻoʻopu and ʻōpae (shrimp) that have been washed downstream by the rain.

Kau ke poʻo i ka uluna o Welehu ka malama.
(Rest the head on the pillow; November is the month.)

This proverb refers to the time of year when work is done, weather is stormy, and people can rest.

Conservation Notes:

Makaliʻi / December

Ka iʻa kāohi aho o na kai uli.
(The fish of the deep that pulls the line taut.)

This proverb refers to the ulua, a strong fish, or to a strong, young man. Ulua aukea (giant trevally) finish spawning during this month. If you catch a young, small ulua, let it go! They don't spawn until they are 3.5 years old and approximately 21 inches long.

Naueue ka hiʻu o ka iʻa lewa i ke kai.
(The tails of the fish that move in the sea tremble.)

The kapu season begins now for the ʻamaʻama (striped mullet). The adults spawn in the open ocean where stable salinity and temperature conditions are good for the growth of their newly hatched fish.

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Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources. http://www.hawaii.gov/dlnr/dar. (Provides information about spawning seasons and related Hawai'i fishing regulations)

LaMotte Company. <mkt@lamotte.com> www.lamotte.com/ P.O. Box 329, 802 Washington Avenue, Chestertown, MD 21260 (800) 344-3100. (Products for the analysis of water, soil, and air)

Missouri Botanical Gardens. *Currents, Waves & Tides.* (Copyright © 2003 Missouri Botanical Gardens) <jennifer.krause@mobot.org> http://mbgnet.mobot.org/salt/motion/ (Biomes of the world, freshwater and marine ecosystems)

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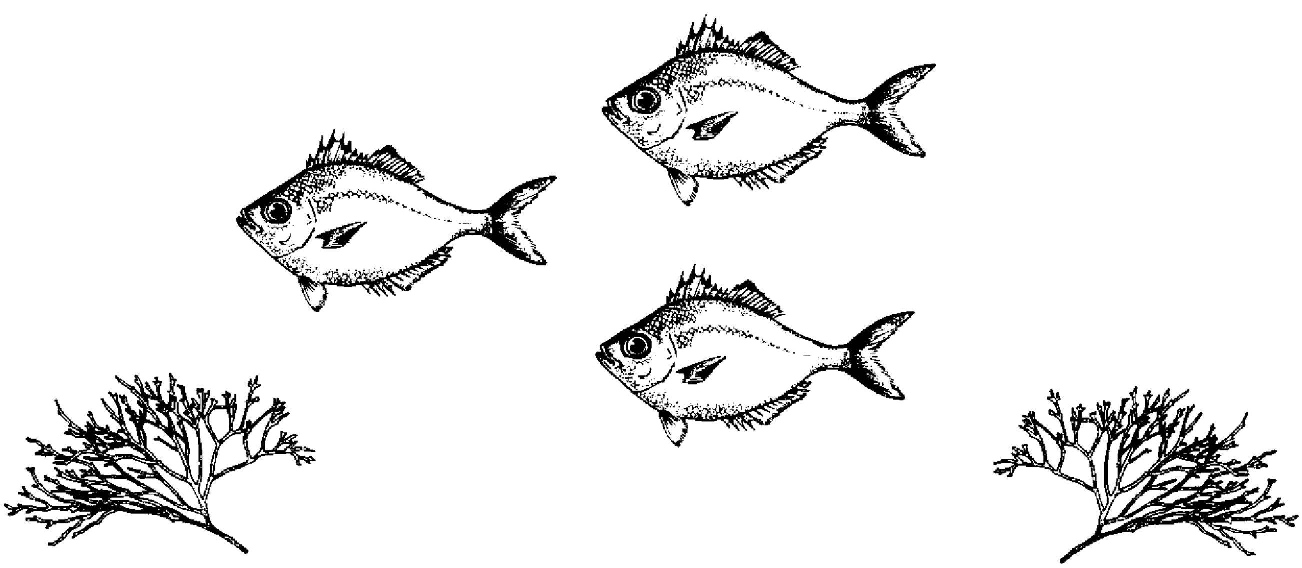
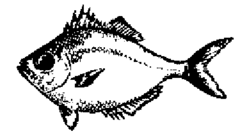


Unit 2 at a Glance



Grades 9 - 12

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: Cycle of Matter and Energy Flow Explain what happens to energy and matter as the chemical elements flow through each level in a food web.	**2E.** Why were fishponds more efficient than ocean fishing for providing protein in the diet of early Hawaiians? **Activity:** ***Passing on the Energy***	• Organisms are linked to each other through the cycling of matter and flow of energy through food chains. • Energy is lost at each level in a food chain, so the more simplified fishpond ecosystem was more efficient than an ocean ecosystem at providing protein. • Organisms need energy for life functions such as growth, respiration, and reproduction. Energy is not destroyed – it is just converted from an ordered, concentrated form such as the chemical energy in food, into a more dispersed and less useable form such as heat energy.	Students: • Diagram an ocean food chain and a fishpond food chain and note the energy loss at each step in the chain. • Write an explanation of why fishponds were more efficient than ocean fishing for providing protein for early Hawaiians.
Mālama I Ka ʻĀina: Conservation of Resources: Analyze, evaluate and propose possible solutions in sustaining life on Earth, considering the limited resources and fragile environmental conditions.	**2F.** What are the interrelationships among plants and animals in a fishpond ecosystem? **Activity:** ***Investigating Interrelationships***	• Organisms in a fishpond are interdependent and vulnerable to human induced changes to their environment. • Introduced species often compete with native species and have a negative impact on both aquatic and terrestrial environments.	Students: • Illustrate the interdependence and interrelationships within the fishpond ecosystem. • Write a summary of how invasive limu species could affect the balance of life in a fishpond.

Culminating Activity

Students develop a fishpond model to illustrate the interdependence and interrelationships within the ecosystem and the impact of human changes on the system. Students present their models and propose solutions to negative impacts of human activities on fishponds. Models may take the form of fishpond replicas using clay or cinders for pond walls (see *Engineering Ingenuity* in Unit 3 for ideas), computer models, or games that students create by designing playing cards from data they collect during a fishpond field trip.

Students' models should: a) provide examples of at least four interrelationships within a fishpond ecosystem; b) demonstrate what happens to energy as it moves through the ecosystem; c) illustrate the consequences to the ecosystem of a human impact, such as a change in water quality or an introduced species; and d) include a proposed solution to the negative consequences of the human impact.

Review criteria for assessing students' models and presentations and have them work with you to develop a rubric (see sample rubric provided).

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	'Ano Mākaukau (Almost at Standard)	Mākaukau 'Ole (Below Standard)
Science: Mālama I Ka 'Āina Design a model to illustrate the interdependence and interrelationships within a given ecosystem. ***Points*** _____	Model illustrates four or more interrelationships within the fishpond ecosystem and clearly demonstrates the interdependence among species.	Model illustrates the interdependence and interrelationships within the fishpond ecosystem; provides sufficient examples to communicate effectively.	Model illustrates some of the interdependence or interrelationships within the fishpond ecosystem, but it needs more examples.	Model does not illustrate interdependence or interrelationships within the fishpond ecosystem.
Analyze the consequences of change on the entire system and propose solutions to negative consequences. ***Points*** _____	Model clearly analyzes consequences of human changes to the system. Solutions proposed to the negative consequences show evidence of critical analysis.	Model clearly analyzes consequences of human changes to the system and proposes thoughtful solutions to the negative consequences.	Model analyzes consequences of human changes to the system, but does not propose adequate solutions.	Model does not show consequences of human changes to the system or propose solutions.
Science: Cycle of Matter and Energy Flow Compare the path of energy and matter through a living system. ***Points*** _____	Model clearly shows the difference between the path of energy and matter in the system and describes how they are different.	Model clearly shows the difference between the path of energy and matter in the system.	Model shows the path of energy or matter in the system, but not both.	Model does not show the path of energy or matter in the system.
Model Design ***Points*** _____	Model design enhances understanding of content; has high visual appeal.	Model design supports content and is appropriate in quality.	Model design is minimal and not entirely effective.	Model design is incomplete or not appropriate.

I NOTICED:

Passing on the Energy

- Why were fishponds more efficient than ocean fishing for providing protein in the diet of early Hawaiians?

Hawai'i DOE Content Standard

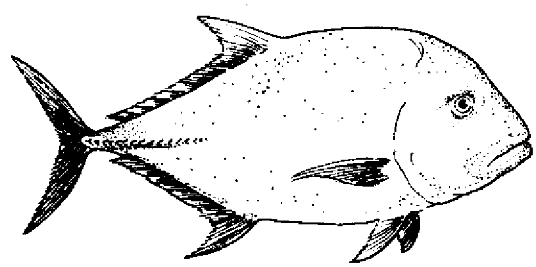
Science: Cycle of Matter and Energy Flow
Students trace the cycling of matter and the flow of energy through systems of living things.

Grades 9 - 12 Performance Indicator

Biological Performance Indicator:
- Compare the path of energy and matter through a living system.

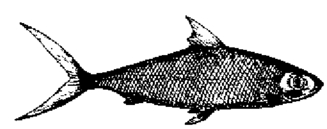
Key Concepts

- Organisms are linked to each other through the cycling of matter and flow of energy through food chains.
- Energy is lost at each level in a food chain, so the more simplified fishpond ecosystem was more efficient than an ocean ecosystem at providing protein.
- Organisms need energy for life functions such as growth, respiration, and reproduction. Energy is not destroyed – it is just converted from an ordered, concentrated form such as the chemical energy in food, into a more dispersed and less useable form such as heat energy.



Prerequisite

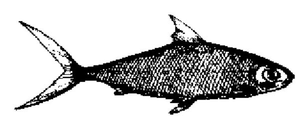
Ka Hana No'eau a nā Kūpuna, Huaka'i (Field Trip) 1, Unit 1



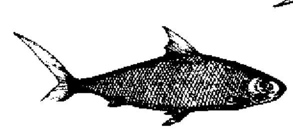
Activity at a Glance

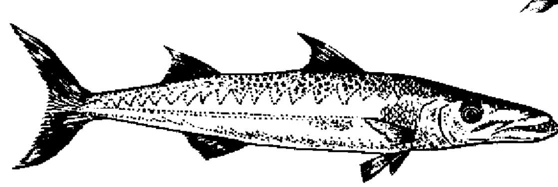
Students model two different food chains to compare the amounts of caloric energy available in an ocean food chain and in a fishpond food chain.

Skills



modeling, measuring, analyzing, problem-solving

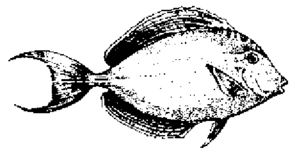




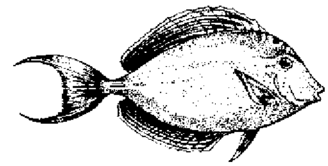
Assessment

Students:
- Diagram an ocean food chain and a fishpond food chain and note the loss of energy at each step in the chain.
- Write an explanation of why fishponds were more efficient than ocean fishing for providing protein.

Time



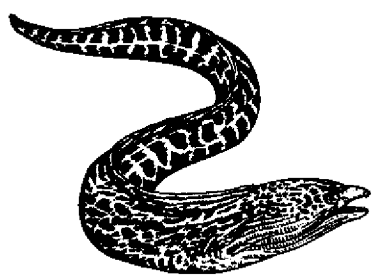
1 class period



Vocabulary

algae – limu; aquatic plants and organisms containing chlorophyll
food chain – a series of organisms interrelated in their feeding habits, the smallest being fed upon by a larger one, which in turn is eaten by an even larger one
food web – a series of organisms related by predator-prey activities; a pattern of predator-prey relationships in a community of organisms
ecosystem – a system formed by the interaction of a community of organisms with their environment
caloric energy – energy from food (measured in calories)
heat energy – a form of energy that causes a rise in temperature, expansion, evaporation, or other physical change
efficiency – ability to accomplish something with a minimal amount of time and energy
plankton – microscopic animal and plant life floating in bodies of water
phytoplankton – the plant organisms in plankton

Materials



Provided
- pond life cards (in Appendices)

Needed
- calorie counter booklet
- string
- scissors
- ruler or meter stick
- signs or labels titled *Fishpond*, *Ocean*, and *Used Energy*

Advance Preparation

Make copies of the pond life cards provided in the Appendices. Adjust the number of cards to fit your class size. Based on a class of 25 students, copy the following: 4 limu kala, 10 phytoplankton, 4 pualu, 4 awa, 2 āholehole, and 1 ulua. Laminate the pond life cards (or staple them onto index cards), punch two holes at the top, and thread a string through the holes so that the students can hang the cards around their necks. Cut two 10-meter lengths of string.

To find out how many calories are burned during various activities, obtain a copy of a calorie counter booklet or obtain the information online at:

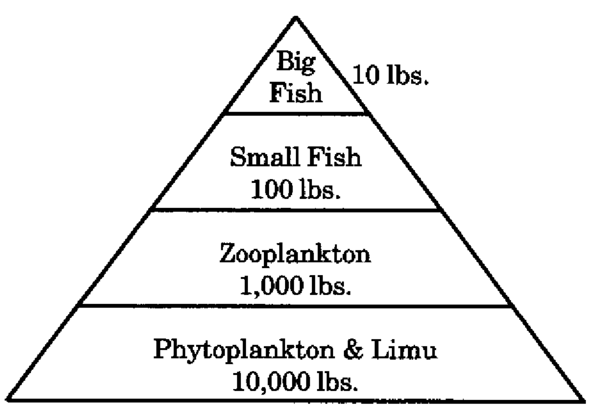
http://www.caloriecountercharts.com/chart2a.htm, or
http://www.bhg.com/home/Food-Calorie-Chart.html, or
http://www.caloriesperhour.com/

Background

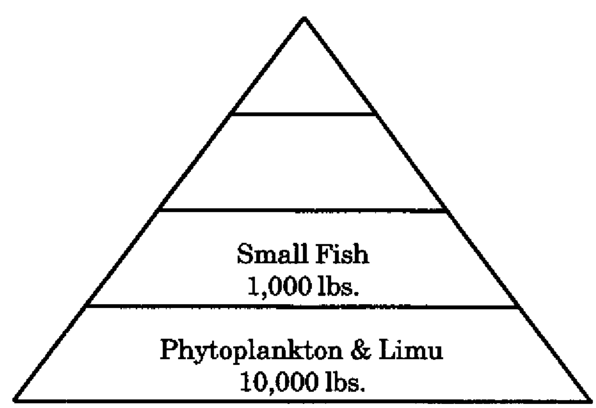
Fish and shellfish provided the major part of the protein needed by the early Hawaiians, and the oceans around the Hawaiian Islands contained a plentiful supply. Ocean fishing, however, is dangerous, time-consuming, and depends greatly on weather conditions.

By raising herbivorous fish in fishponds, the early Hawaiians were able to assure a plentiful supply of protein in a much more efficient way. During World War II an important bit of research was done by Professor W. Hiatt at the University of Hawai'i (1947). He discovered something the Hawaiians had known for at least 500 years and maybe even longer. It was this: "The most efficient way to produce protein for human consumption is to cultivate the herbivor [sic] link in the food chain – cultivate the fish that only eat algae (limu). Hiatt felt this discovery revealed the true genius of the Hawaiians" (Dieudonne, 2002). As a rule of thumb, 90 percent of the caloric value of a plant or animal is lost to respiration and other bodily functions at each step in a food chain.

- 10,000 pounds of limu (algae) is enough to raise 1,000 pounds of herbivorous 'ama 'ama (striped mullet fish).
- 10,000 pounds of limu in the ocean ecosystem will only produce about 10 pounds of large, carnivorous fish - the kind usually targeted by ocean fishers (Henry, 1993).



Ocean Food Pyramid



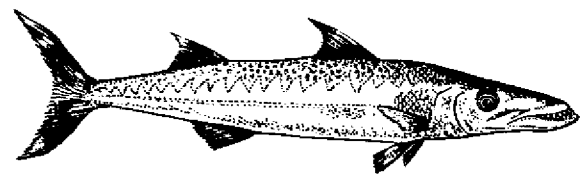
Fishpond Food Pyramid

Energy Needs

An organism's most basic need is for energy. To get energy, it needs food as a fuel and oxygen to burn it. All animals depend on plants, which capture the sun's energy and through the process of photosynthesis produce sugars and oxygen. Limu and microscopic phytoplankton in the ocean are the producers in the food chain. Phytoplankton, which comprise more than 99 percent of all the plant life in the ocean, are the most important producers.

The amount of energy foods can produce is measured in units called calories. A food calorie, or kilocalorie, is the amount of heat required to raise the temperature of 1 kilogram (2.2 pounds) of water 1 degree Celsius (1.8 degrees Fahrenheit). The reason that so much energy (90 percent) is lost at each level in the food pyramid is that organisms use energy for living functions such as growth, respiration and reproduction. The body changes the calories in food into energy, which is necessary for every act from blinking an eye to running a race, rebuilding damaged cells, or regulating body systems. The energy is not destroyed – it is just converted from an ordered, concentrated form such as the chemical energy in food, into a more dispersed and less useable form such as heat energy.

Teaching Suggestions



1. Introduce the concept of caloric energy in food by asking the students what they had for breakfast, or what some of their favorite foods are. Write some of the common foods on the board. Use a calorie counter booklet or information on the Web, and ask a student to look up the numbers of calories in each of the food items. Discuss the ways in which food gives them energy for their daily activities and how caloric energy from food is converted to heat energy. Also discuss why we need protein in our diets, and what kinds of food provide it.

2. Review the concept of food chains and food webs with students. Hold up 10 meters of string and explain that this represents the total amount of "energy" that is stored in 10,000 pounds of producers--limu and phytoplankton. Ask students:

   Could you feed fish to more people from this amount of limu and phytoplankton if the fish came from an ocean ecosystem or a fishpond ecosystem? Why?

3. Record the students' ideas on the board. Explain that students will model a simple food chain in each of the two ecosystems to find out which is more efficient at providing protein. Put the *Ocean* label on one side of the room and the *Fishpond* label on the other. Place the *Used Energy* label in the center of the room.

   Modeling Food Chains:

   - Choose 2 students to represent the people who need fish to eat. One will get fish from the ocean; the other fish from the fishpond.
   - Choose 5 students to represent the phytoplankton and 2 to represent the limu in the ocean ecosystem, and repeat the same step with 7 additional students for the fishpond. Ask them to stand near the appropriate signs.
   - Distribute the remaining organism cards. Ask the 4 students representing pualu (surgeonfish), 2 representing āholehole (flagtail fish), and 1 representing the ulua (jack or trevally fish) to stand near the *Ocean* sign.
   - Ask the 4 awa (milkfish) to stand near the *Fishpond* sign.

4. Starting with the ocean ecosystem, give 10 meters (1000 cm) of string to the limu and phytoplankton. Remind the class that this is the total amount of energy (calories) stored in these producers.

5. Ask the students which fish would eat the limu and phytoplankton and get this energy *(the pualu)*. Remind the students that before they pass the energy to the pualu, they will need to use a certain amount of it for their own living and growing needs. Ask them if they know how much of the energy they will be able to pass on *(only about 10 percent)*. Have the students measure 10 percent of the string (100 cm) and cut it off. The remaining 900 cm goes into the *Used Energy* pile.

6. Now, ask which fish will eat the pualu *(the āholehole)*. How much energy can the limu and pualu pass on to the āholehole? *(10 percent = 10 cm)*. Have the students measure and cut the string and put 90 cm into the *Used Energy* pile.

7. Repeat the process for the next step in the chain, and have the students measure and discard 9 cm of string, and pass 1 cm to the ulua. How much energy does the ulua need for its life processes, and how much can be passed on to the humans? *(The ulua needs 90 percent, leaving 0.1 cm for the humans.)* Have the students attempt to measure and cut the string, discarding the larger portion and giving the tiny bit remaining to the human.

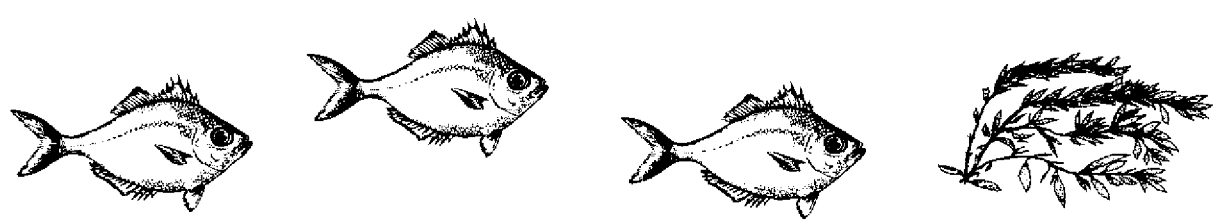
8. Repeat the process for the fishpond ecosystem – the phytoplankton and limu start with 1000 cm of energy and passes 100 cm to the awa. The awa then passes 10 cm to the human.

9. Introduce the ocean and fishpond food pyramids and discuss the models with the students.

   Discussion Questions

   - Which ecosystem is more efficient from the point of view of producing fish for human consumption? Why?
     (the fishpond, since it has fewer levels for energy to be lost)
   - What happens to the energy at each level in the food chain? And why is so much energy lost at each level?
     (The energy is not destroyed – it is just converted from an ordered, concentrated form such as the chemical energy in food, into a more dispersed and less useable form such as heat energy. Energy is lost at each level because organisms use it for living functions such as growth, respiration, and reproduction.)
   - How do these models differ from what actually happens in an ocean or fishpond ecosystem?
     (Models are simplified examples of what happens in reality. Students demonstrated the concept using only simple, linear food chains. A real ecosystem is much more difficult to analyze. Complex food webs with other herbivores and predators and other factors such as water temperature and quality and weather conditions could affect the outcome.)
   - What other factors make fishponds more efficient for providing fish than ocean fishing? *(It takes less energy to catch a fish in a pond than in the ocean. It is easier to catch fish in a pond than in the ocean during stormy weather conditions.)*

10. Ask students to complete the assessment activity - draw both the ocean and fishpond food chains and show the amount of energy converted at each step in the chain.



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Metric Units and U.S. Equivalents

Unit	Abbreviation	Number of Meters	Approximate U.S. Equivalent
kilometer	km	1,000	0.62 mile
hectometer	hm	100	328.08 feet
dekameter	dam	10	32.81 feet
meter	m	1	39.37 inches
decimeter	dm	0.1	3.94 inches
centimeter	cm	0.01	0.39 inch
millimeter	mm	0.001	0.039 inch
micrometer	μm	0.000001	0.000039 inch

Mass and Weight

Unit	Abbreviation	Number of Grams	Approximate U.S. Equivalent
metric ton	t	1,000,000	1.102 short tons
kilogram	kg	1,000	2.2046 pounds
hectogram	hg	100	3.527 ounces
dekagram	dag	10	0.353 ounce
gram	g	1	0.035 ounce
decigram	dg	0.10	1.543 grains
centigram	cg	0.01	0.154 grain
milligram	mg	0.001	0.015 grain
microgram	μg	0.000001	0.000015 grain

6

Investigating Interrelationships

- What are the interrelationships among plants and animals in a fishpond ecosystem?

Hawai'i DOE Content Standard

Science: Mālama I Ka 'Āina

- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 9 - 12 Performance Indicator

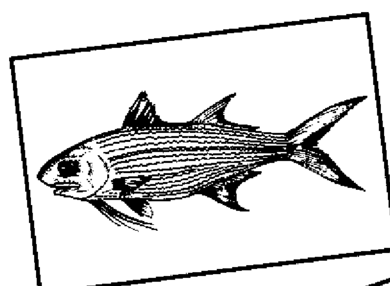
CONSERVATION OF RESOURCES
Design a model to illustrate the interdependence and interrelationships within a given ecosystem.

Key Concepts

- Organisms in a fishpond are interdependent and vulnerable to human induced changes to their environment.
- Introduced species often compete with native species and have a negative impact on both aquatic and terrestrial environments.

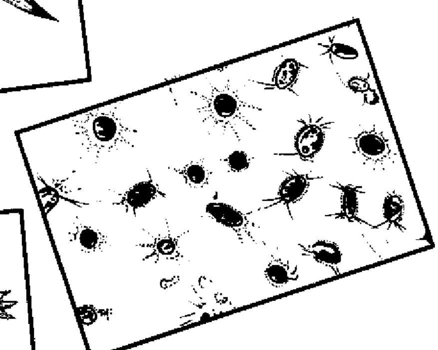
Prerequisite

Passing on the Energy



Activity at a Glance

Students use pond life cards to discover interrelationships, make predictions about the species they will find on a fishpond field trip, and draw diagrams to summarize the interrelationships among species in a fishpond ecosystem.



Skills

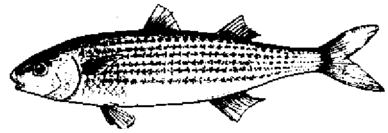
communicating, analyzing, illustrating

Assessment

Students:

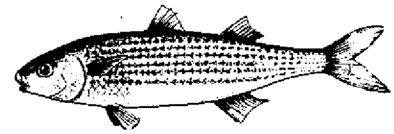
- Illustrate the interdependence and interrelationships within the fishpond ecosystem.
- Write a summary of how invasive limu species could affect the balance of life in a fishpond.

Time



2 class periods

Vocabulary

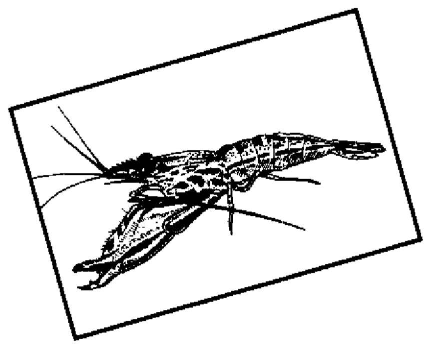


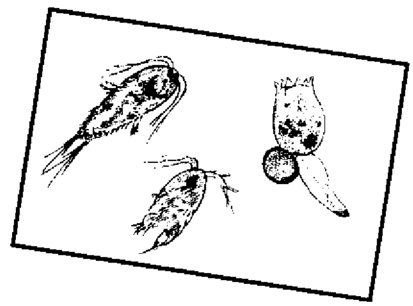
ecosystem – a system formed by the interaction of a community of organisms with their environment
endemic – native to an area; occurring naturally nowhere else
indigenous – native to an area, but also occurring naturally in other areas
introduced –brought in or established, as something foreign or alien
diatoms – unicellular or colonial phytoplankton whose cell walls contain silica

Materials

Provided
- pond life cards (see Appendices)

Needed
- paper
- pens
- tape



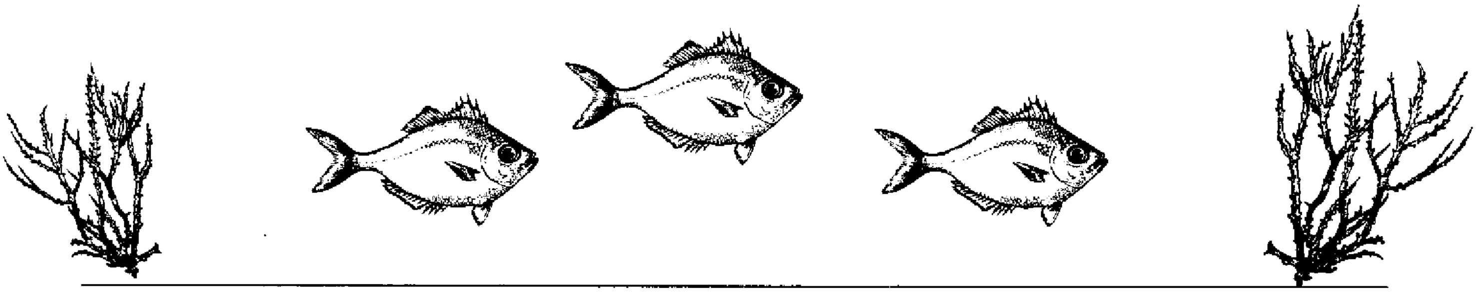


Advance Preparation

Copy the pond life cards (provided in Appendices). If necessary, make extra copies of some of the cards so that there is one card per student. Make three large labels "endemic" "indigenous" and "introduced" and tape them in different areas of the classroom.

Background

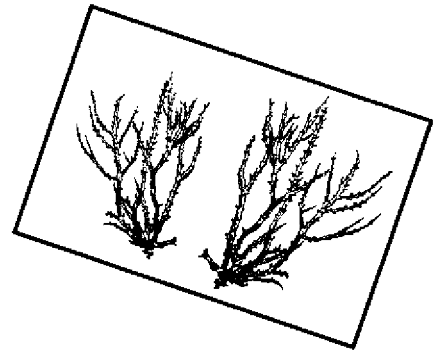
Within the fishpond, all organisms are interdependent and each plays a role in the ecosystem. Microscopic plants—the phytoplankton—form the basis of the food chain, converting the sun's energy into sugars and oxygen in the process of photosynthesis. Tiny zooplankton feed on the phytoplankton. The ʻoʻopu (gobies) are bottom feeders that eat limu (algae) and invertebrate larvae. The herbivorous fish—the awa and the ʻamaʻama (striped mullet)—feed on the phytoplankton and the pond scum (filamentous algae that becomes a free floating mass as it produces oxygen). Predators, such as the ulua (giant trevally) and kākū (barracuda) feed on the herbivores. And crabs scuttling along the pond's floor are scavengers helping to break down decaying organic matter, which enables nutrients to be made available to plants. These interrelationships help to keep the system in balance. However, this balance is disrupted when one species becomes too dominant. The introduction of non-native species, some of which are invasive, is having a negative impact on the balance of marine ecosystems in the Islands.



Diversity of Marine Life in the Hawaiian Islands

Group	Estimated no. of Species	Endemic
Native Species		
Fish	557	24%
Algae	482	10%
Invertebrates	5,349	32 – 35%
Introduced Species (established)		
Fish	20	
Algae	24	
Invertebrates	287	

Source: Presentation by Kevin Foster, U.S. Fish and Wildlife Service, to the Waikīkī Aquarium Marine Alien Species in Hawai'i Teacher's Workshop, February 2002.



Acanthophora spicifera *has become the most common invasive seaweed worldwide. It is an invader to Hawaiian waters and has been shown to compete with our native limu species.*

Non-native species have been introduced to Hawaiian waters as attachments on the hulls of commercial and recreational boats, through marine debris, accidentally by the aquarium industry, or through release by researchers. Of the 24 introduced species of algae, seven species have become invasive. These species pose a significant threat to the biological diversity of the native marine life. The invasive limu species compete with native species, in some cases growing into a thick mat, which covers a reef and blocks sunlight, killing coral, native limu, and reef micro-organisms.

Invasive Limu in the Hawaiian Islands

Species	Date of Introduction	Island 1st Found	Number of Islands	This study - New Island Records
Acanthophora spicifera	after 1950	O'ahu	Hawai'i, Maui, Moloka'i, Lāna'i, Kaho'olawe, O'ahu, Kaua'i	*
Eucheuma denticulatum	1970	O'ahu	O'ahu	*
Kappaphycus striatum	1970	O'ahu	O'ahu	*
Gracilaria salicornia	1971	O'ahu	O'ahu, Hawai'i, Moloka'i	Moloka'i
Hypnea musciformis	1974	O'ahu	Maui, Moloka'i, Lāna'i, O'ahu, Kaua'i, Necker, Maro Reef	Kaua'i
Kappaphycus alvarezii	1974	O'ahu	O'ahu	*
Avrianvillea amadelpha	1981	O'ahu	O'ahu	Kaua'i

Source: Smith, Jennifer. 2003. *Alien & Invasive Algae in Hawaii*. University of Hawai'i at Mānoa Botany Department. <jesmith@hawaii.edu.> http://www.botany.hawaii.edu/GradStud/smith/websites/Alien-Bishop.htm.

Teaching Suggestions

1. Distribute one pond life card to each student. Ask students to read the information on the card and write a brief summary with the following information:
   - Name at least two other organisms that are interdependent with the species on your card.
   - Predict whether you will see the organism described on your card when the class visits a fishpond, and describe where in the pond you might find it (for example, in bottom sediments, in crevices in the wall, or not visible). Explain.
   - Describe whether you believe the organisms will be abundant, relatively common, or rare, and state why.

3. Give students a few moments to think about the information and record their ideas.

4. Select four students and have them come to the front of the classroom with their pond life cards. Challenge them to circulate around the classroom and find other students with pond life cards that will form interrelationships with theirs. When they find a card that has an interrelationship (it eats their species or is eaten by it) they should ask that student to join them and look for additional species.

5. Challenge students to link up with as many students as possible in a three - five minute time period. When time is up, have groups explain the interrelationships among species on their cards. Check to see if they are correct and declare the group with the most interrelationships to be the "winner."

6. Explain that the interrelationships help us to define the fishpond ecosystem, which is formed by the interaction of this community of organisms with their environment. (If students need a review of basic ecological concepts, refer to the Grades 4 – 5 *Recipe for a Fishpond* activity in this unit.)

7. Ask students to take their pond life cards and notes and go to one of the three areas in the classroom that matches the status of the species on their card (endemic, indigenous or introduced). Review the differences between "endemic," "indigenous," and "introduced."

8. Have students share what they have written about the species on their pond life cards. Which species do they predict will be most abundant at the pond? (Keep their predictions and review them again before going to the fishpond; see Unit 4.)

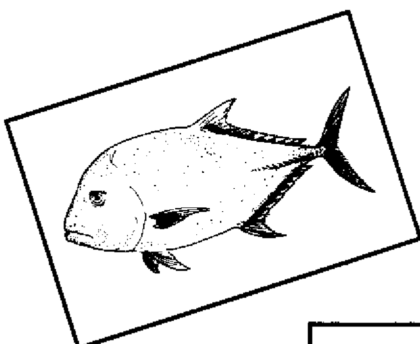
9. Ask the students who have the invasive limu pond life cards to share information about the problems posed by these invaders.

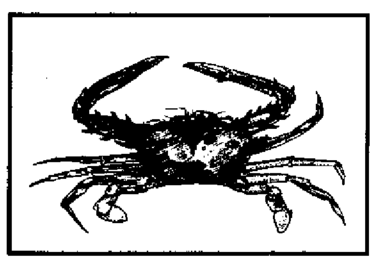
10. Have students complete the assessment activity by designing illustrations that show the interrelationships within a fishpond ecosystem. Have them create a caption for the illustration that describes how the balance of the system could be affected by invasive limu species.

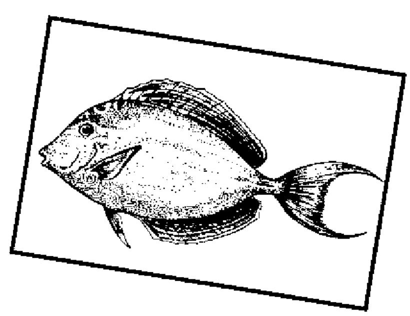
Extensions/Adaptations

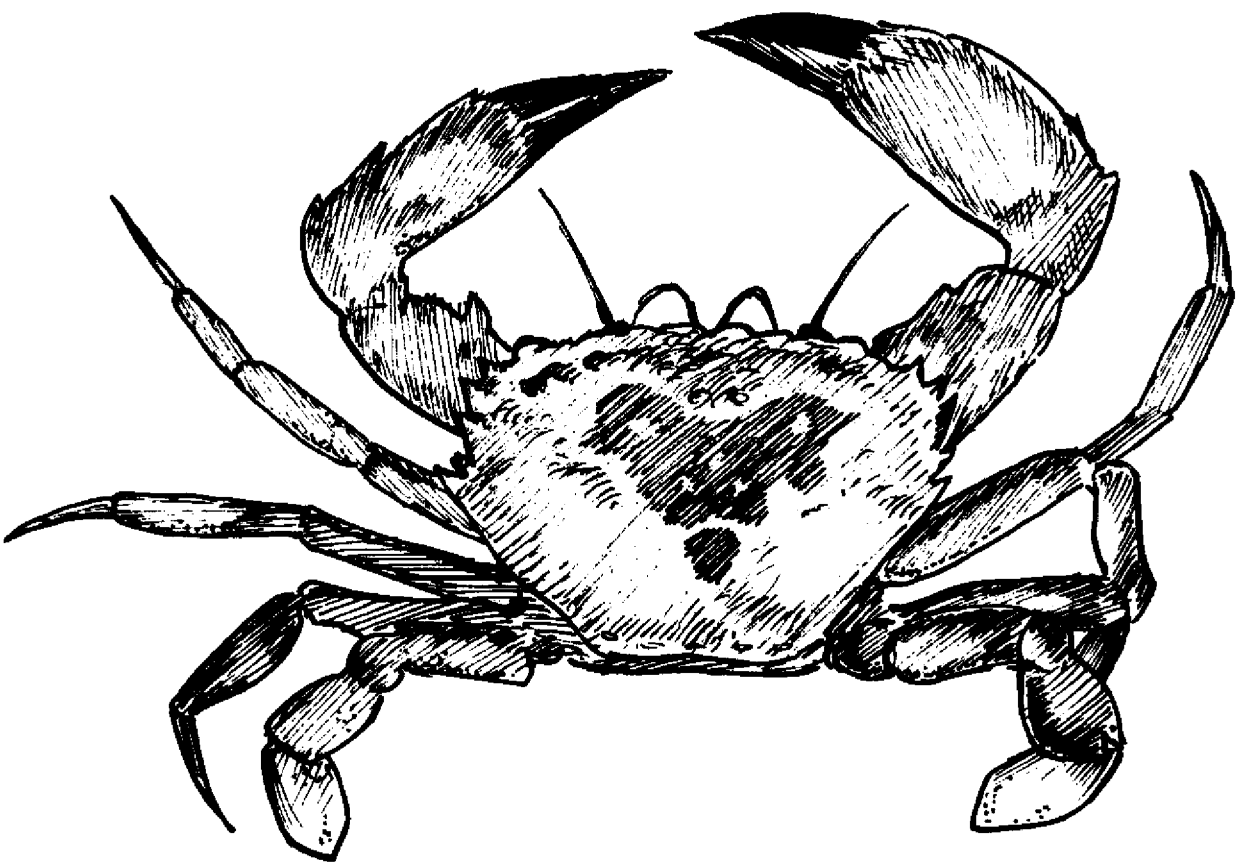
- Refer students to information on the Web about studies being conducted by scientists to monitor invasive algal species. See http://www.botany.hawaii.edu/reefalgae/. Click on Marine Plant Research, Hawaiʻi Coral Reef Initiative. The invasive algal species pages have photographs and maps showing abundance of species by island. Ask students to review the algal species pages on the Web and identify which species are invading on your island and which pose future threats.

- Collect small samples of limu that are common in your area. Refer to the pond life cards and the photographs provided on the Web to identify the species. If native species are collected, be sure to leave the base of the plant intact so that it can regenerate. (Refer to http://www.botany.hawaii.edu/invasive/.) Place the limu in bowls of seawater for students to examine and identify before going to the pond.





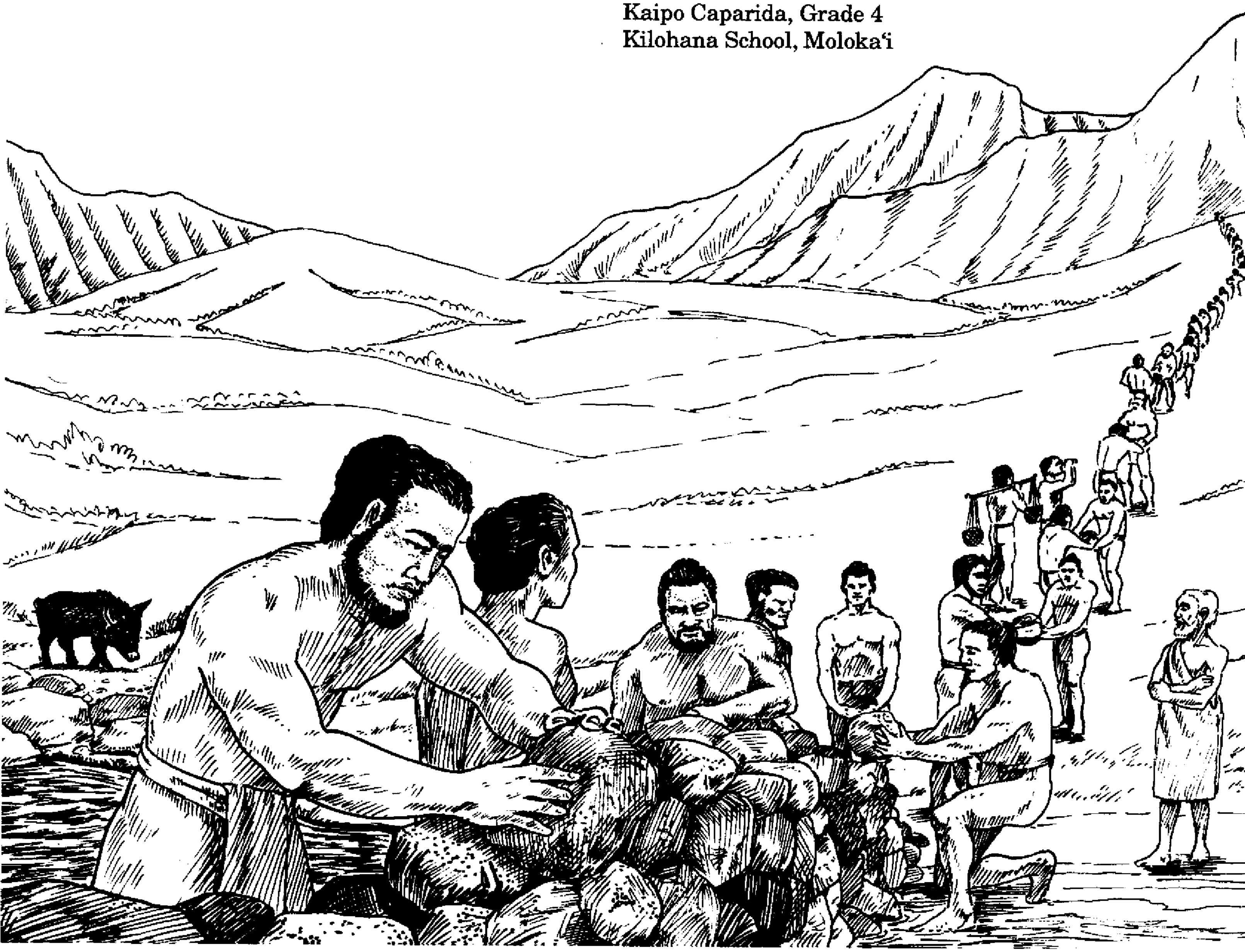


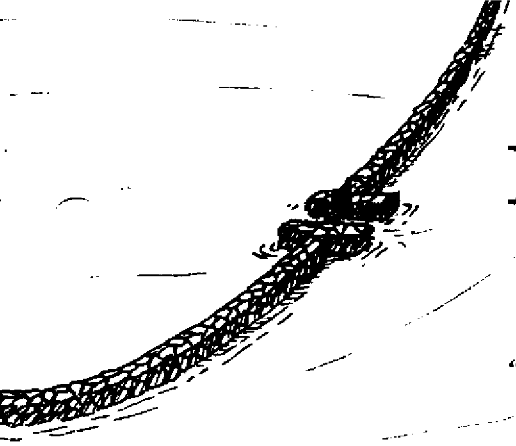


UNIT 3
Early Hawaiian Fishponds

"A Hawaiian fishpond is like an ancient guardian who keeps the food."

Kaipo Caparida, Grade 4
Kilohana School, Moloka'i





Early Hawaiian Fishponds

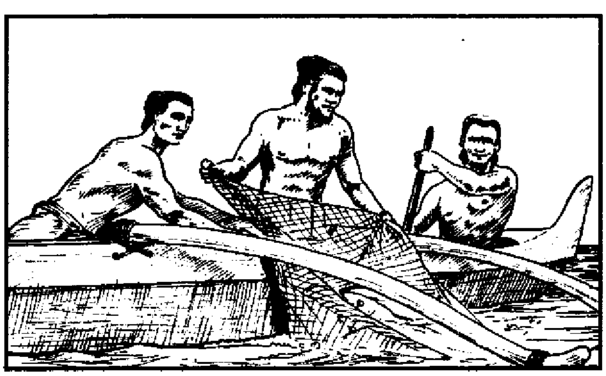
"O ka na'auao o nā kūpuna ka lama e ho'omālamalama i ke ala no nā keiki. - The wisdom of the elders is the torch that enlightens the path of the children."

Gary Kahaho'omalu Kanada (1998)

Early Hawaiians were keen observers of ocean currents and tides. Using the ocean swells to help navigate their canoes, they embarked on long journeys across the Pacific. For sport, they rode the waves on their surfboards. As fishers, they were alert to every movement in the ocean water and could predict a change in the seasons.

The art of fishing was passed down from generation to generation. Having observed the natural talents of any particular child, ka po'e kahiko (the people of old) would seek established scholars familiar with the child's interest to pass on knowledge. Over a period of many years, some say 20 years, of apprenticeship, the oral history or skill was passed from one generation to another. Children of fishers or farmers or canoe makers would be expected to learn the skills needed to excel in a certain area of expertise.

So vast was the fishers' knowledge of the natural environment that their observations led to the development of a variety of fishing methods and fishing implements, and eventually to sophisticated engineering involved in growing fish in different types of fishponds and fishtraps.



Early Fishing Methods

One of the earliest and simplest methods of catching fish was by hand. "Men and women would grope in holes or crevices that were likely habitats, grasp the fish, and put them into bags strung around their waist" (Wyban, 1992). Other methods included prodding in crevices with a stick, ensnaring between the fingers, striking with loose stones, or using plant compounds to drug the fish. In the mountain streams, dams were built to block the flow of water. The maka'āinana would stamp the waters, disturbing the sediment below, which forced the 'o'opu (goby) fish to surface for air (Wyban, 1992). This made it easier to catch and bag the 'o'opu.

But these methods were not considered expert ways of fishing. "They were just for the taking of fish to make living more pleasurable – to have something for the family and guests to eat with poi" (Kamakau, 1976). Far superior were methods of diving for fish and fishing with long lines. To acquire the proper equipment for ocean fishing, the fisher had to be recognized as a true fisher. Not everyone held this distinction. "If (he) were a landholder or chief, or a descendant of a fisherman, or a son in a family which had ʻaumakua (a family god) of fishing, then he could be a true fisherman with no lack of long canoes, short canoes, light, swift canoes, large and small nets, and long and short fishing" (Kamakau, 1976).

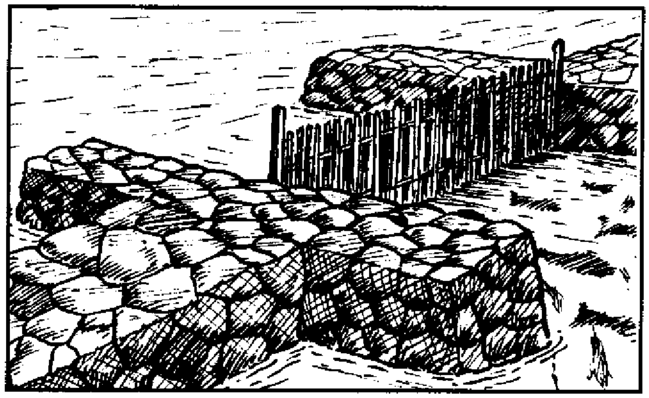
There were many methods of fishing. Spear fishing, which was commonly done under water, required the fisher to aim in front of the fish to hit it when it moved forward. Other methods employed fish lines, fishhooks and fish lures. Various types of nets were used to catch specific kinds of fish. Mesh nets, dip nets, gill nets, seines and bag nets were commonly used. Portable fishtraps made from vines and cordage and fashioned into basket, funnel and cylindrical shapes were used to catch fish in fresh water as well as salt water (Wyban, 1992).

Sustainable Practices

The early Hawaiians practiced sustainable farming and aquaculture because their very existence depended upon it. The elders taught that whatever was taken from the land or sea, a gift had to be given in return. They were taught to only harvest what was needed from the mountains and the sea, for example, to harvest ferns and limu without damaging the roots and shoots so that growth of the plants would continue, to return fish with eggs to the sea, and to leave large ʻopihi so that they could spawn. Strict kapu (taboo) were placed on catching of certain fish during their periods of reproduction.

Growing Fish

The evolution from catching fish to growing fish was a joint effort between the farmer and the fisher. On land, the farmer was responsible for the irrigation system of his loʻi kalo (taro patches). "The original concept of the mākāhā may have been developed in the agricultural irrigated taro plots, where rudimentary mākāhā of smaller



mākāhā

scale occur to control water flow into plots" (Kikuchi, 1973). While in the ocean, the fisher observed the ocean current and tides and the movement of fish and implemented techniques to catch his food. The combined knowledge of the farmer and fisher led to the development of the sophisticated technological system of the mākāhā. The mākāhā was a stationary grate placed into an opening or canal (ʻauwai kai) that was built into the wall of the loko kuapā.

> *When the stone walls of the kuapā shore ponds were completed, then the task remained to find the proper wood for the sluice gate, the mākāhā. This was selected by the kahuna of the ʻaumakua who increased fish in the ponds (kahuna ʻaumakua hoʻoulu iʻa loko kuapā). The wood was ʻohiʻa ʻai or lama or some other suitable wood. When the wood for the mākāhā was ready, and the proper day had arrived for its construction, the kahuna was fetched to set up the first piece of timber. For this important duty he offered a pig or a dog suitable to this work of inspiring the increase of fish, and prayers appropriate to this work. Then he reached for a timber and set it up for the mākāhā and offered the pule hoʻona [the prayer that released the kapu and allowed the work to proceed]. Then the men built the mākāhā, binding it together with ʻie cords [aerial root of the ʻieʻie plant]. After that they arranged (hoʻonohonoho) foundation stones with the mākāhā and poured in pebbles. It was in this way that all mākāhā were made.*
>
> \- Kamakau (1869)

The mākāhā most likely allowed the Hawaiians to progress from fishtraps, in which all lanes were open to the sea, to enclosed shore fishponds where access into and out of the pond could be controlled. It was a significant innovation used to circulate water, and it also allowed small fish to enter the fishpond. When the young fish in the pond grew larger than one half inch thick, they could no longer escape to the open ocean through the slits in the grate. Fish could be harvested from the pond as they gathered at the mākāhā during changes in the tide. During the nights of a full moon and high tide when the fish would pour into the sluice, a kia'i loko (pond keeper) was posted near the sluice to guard against 'four footed and two footed' thieves (Handy et al., 1972). The more mature fish could easily be caught by hand.

Once the mākāhā had been introduced, the process of stocking the pond required not nearly as much effort as fishing. One way the early Hawaiian managed to stock the pond was to offer ceremonial prayers and when the moon was full and the tide high, the fish, attracted by the inflow, would appear. In some fishponds, Hawaiians fed the fish sweet potatoes, taro and breadfruit so that they would not only grow fat, but also get used to coming to the edge of the pond for food. When it was time to catch a fish, it was easy, since the fish would be accustomed to gathering near the wall to be fed.

"The leap from catching fish to growing fish underscores the ability of the Hawaiians to integrate all aspects of fish life cycles, behavior, and feeding habits with geology, engineering, and hydrology to create a new form of food production" (Wyban, 1992). The system evolved over years and the mākāhā became not only the means of stocking and harvesting, but also a way to maintain water quality and long-term food production.

The activities in this unit help students to explore how fishing evolved in Hawai'i from catching to growing fish, the ingenuity involved in fishpond engineering, and what traditional practices can teach us about values that are important in Hawaiian culture.

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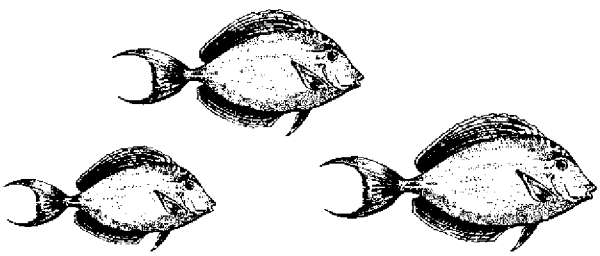
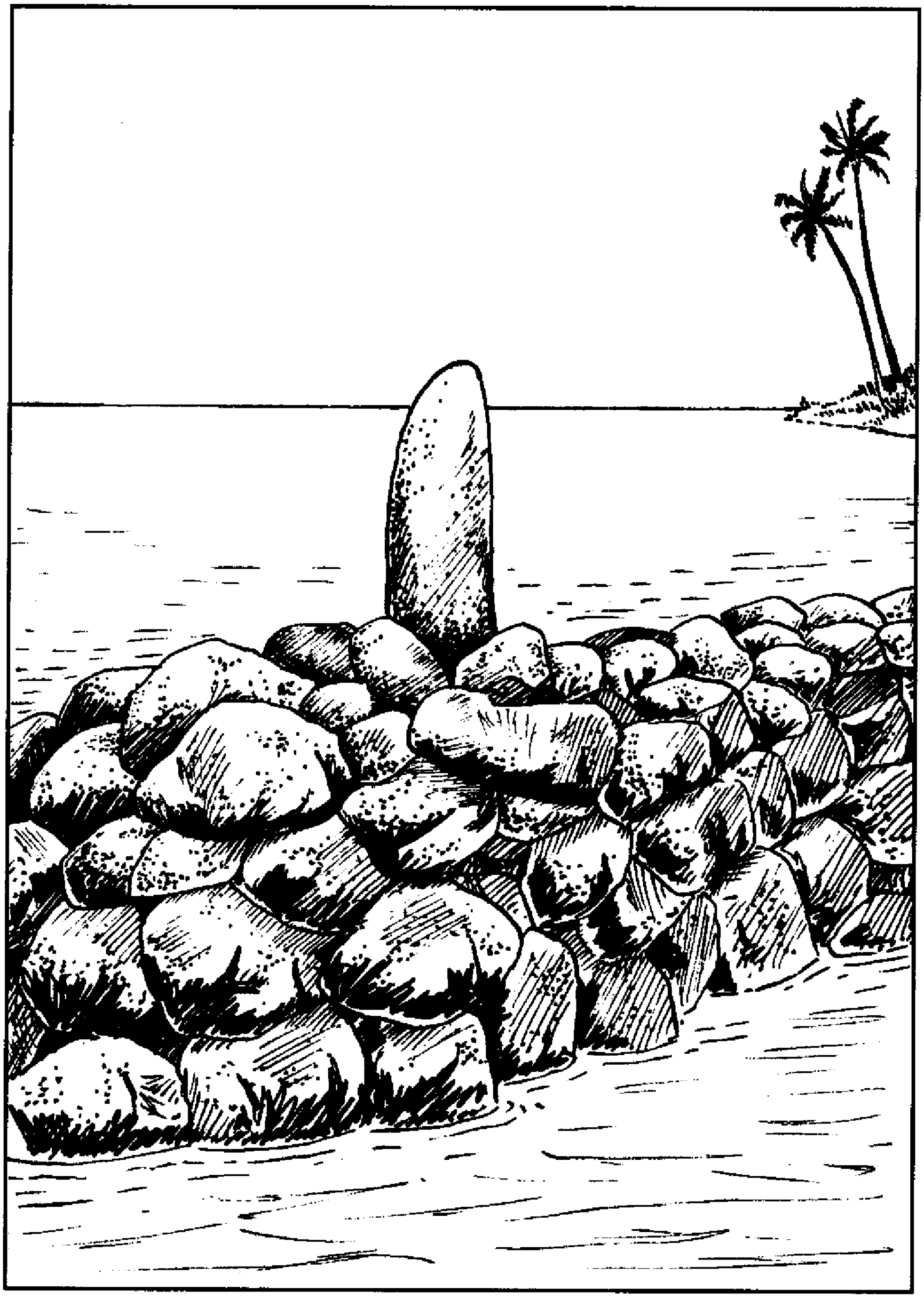
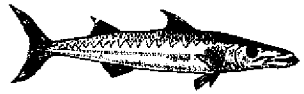




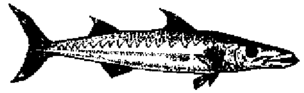
The Kū stone represented Kū'ulakai, the god of fishing.
It was usually placed on the eastern side of the fishpond.

Unit 3 at a Glance

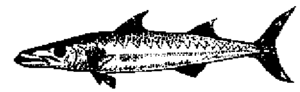


Grades 4 - 5

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: **Mālama I Ka ʻĀina** Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.	**3A.** How did Hawaiians engineer shoreline fishponds to grow fish, while maintaining water quality and preventing siltation? **Activity:** ***Engineering Ingenuity***	• Hawaiians constructed ʻauwai kai (channels) in the walls of shoreline fishponds to create currents that circulated water and attracted fish with each tidal change. They placed mākāhā (sluice grates) in the ʻauwai kai to trap fish. • The circulation of water in the pond aerates the pond with oxygen and flushes out excess sediments and nutrients that can accumulate to unhealthy levels.	Students: • Sketch a loko kuapā, and diagram how the flow of water through the mākāhā at both rising and falling tides affects water quality and pond life.
Science: **Mālama I Ka ʻĀina** Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.	**3B.** Why and how did Hawaiian fishing technology change from catching fish to growing fish? **Activity:** ***Catch It! Grow It!***	• Fishing methods evolved in Hawaiʻi from early techniques of catching fish to the later engineering involved in developing fishponds and growing fish.	Students: • Write a conclusion to the story "The Old White ʻAmaʻama Fish." • Illustrate how fishing technology evolved from catching to growing fish.
Social Studies: **Cultural Systems** Students understand culture as a system of beliefs, knowledge and practices shared by a group.	**3C.** What can traditional Hawaiian fishing practices, moʻolelo (stories), and mele (songs) teach us about values that are important in the Hawaiian culture? **Activity:** ***Haku Mele Aloha***	• Traditional fishing practices, oli (chants), and moʻolelo (stories) express values that are an important part of Hawaiian culture. • Hawaiian values such as hōʻihi (respect) for others and for the land, kuleana (responsibility) for maintaining a balance between self and society and between human beings and the rest of the universe, are expressed through various forms of protocol and moʻolelo.	Students: • Write a description of what traditional fishing practices and a Hawaiian moʻolelo (story) reveal about early Hawaiian life and values. • Compose and share a mele (song) that reveals what a special place in nature means to them.



Unit 3 Culminating Activity



Students write a story or moʻolelo about a fishpond from the point of view of a makaʻāinana (commoner) or aliʻi (chief) in early Hawaiʻi. Their stories describe the beliefs and values that were evident in behaviors and how the fishpond:

- increased food production,
- affected them and the people around them, and
- affected the environment.

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Social Studies: Cultural Systems Interpret and/or illustrate how Hawaiian culture is composed of items (arts, artifacts), ideas (beliefs, values) and behaviors (observable practices that may or may not be related to values and beliefs). ***Points*** ____	Writing clearly describes some of the beliefs and values from the point of view of an aliʻi or commoner in early Hawaiʻi. Writing examines more than one point of view to show how values are reflected in behaviors.	Writing clearly describes some of the beliefs and values from the point of view of an aliʻi or commoner in early Hawaiʻi and makes connections between values and behaviors.	Writing needs more examples to describe the beliefs and values from the point of view of an aliʻi or commoner in early Hawaiʻi.	Writing does not describe beliefs and values from the point of view of an aliʻi or commoner in early Hawaiʻi.
Science: Mālama I Ka ʻĀina Identify agricultural methods used in Hawaiʻi to increase food production and their impact on humans and the environment. (Gr. 4) ***Points*** ____	Writing presents multiple ideas to describe how the fishpond increased food production and how it affected people and the environment. Content goes beyond facts and details to develop ideas; shows critical thinking.	Writing clearly describes how the fishpond increased food production and how it affected people and the environment.	Writing needs more information and focus to clearly describe how the fishpond increased food production or how it affected people and the environment.	Writing needs more information and/ or accurate information.

I NOTICED:

6 Engineering Ingenuity

- How did Hawaiians engineer shoreline fishponds to grow fish, while maintaining water quality and preventing siltation?

Hawai'i DOE Content Standard

Science: Mālama I Ka 'Āina:

- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 4 - 5 Performance Indicators

Grade 4

- Identify agricultural methods used in Hawai'i to increase food production and their impact on humans and the environment.

Grade 5

- Explore how agricultural technology affects humans and the environment.

Key Concepts

- Hawaiians constructed 'auwai kai (channels) in the walls of shoreline fishponds to create currents that circulated water and attracted fish with each tidal change. They placed mākāhā (sluice grates) in the 'auwai kai to trap fish.
- The circulation of water in the pond aerates the pond with oxygen and flushes out excess sediments and nutrients that can accumulate to unhealthy levels.

Prerequisite

Unit 1, *Loko I'a*

Activity at a Glance

Students build model fishponds in shallow pans and experiment with changing water levels outside the pond wall to simulate what happens with the rising and falling tides.

Time

1 - 2 class periods

Skills

modeling, reasoning, interpreting

Assessment

- Students sketch a loko kuapā, and diagram how the flow of water through the mākāhā at both rising and falling tides affects water quality and pond life.

The impressive fishpond walls we see today were built by thousands of workers passing stones from hand to hand.

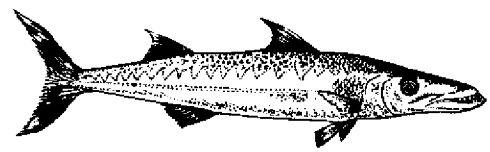
Vocabulary

loko kuapā – seawater fishpond with rock walls built on reef flat
'auwai kai – ditch or small canal, sluice connecting the fishpond to the sea
ingenuity - cleverness or skillfulness of conception or design
mākāhā – sluice grate or gate
nutrient – matter that sustains a living organism and promotes growth
nutrient flushing – the washing away of nutrients
circulation – the moving or flowing of something from place to place or in a circle
siltation – to become filled or choked with silt
stagnation – to become stale or foul from standing, as a pool of water

Materials

Per group of students:

- disposable aluminum roasting pan or shallow plastic dishpan
- 1 block modeling clay
- toothpicks or popsicle sticks
- florist wire that can be cut with scissors
- 2 cups clear water
- 2 cups water, colored blue
- empty 2-liter soda bottle or other container for water
- 2 - 3 feet of flexible tubing or meat baster
- yellow food coloring
- 15 small leaves (to represent large fish)
- oregano or other spice (to represent small fish)



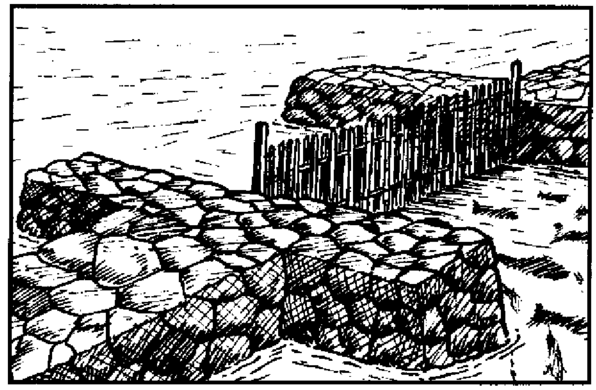
Background

The tidal changes that occur each day are controlled by the gravitational pull of the sun and the moon on the oceans. Our knowledge has evolved to the point where we can now predict when and even how high or low the tide will be for any given day of the year, and we can access that information by simply looking at a tide calendar. During ancient times, the exact mechanism of tidal fluxes may not have been fully understood. However, ancient Hawaiians knew that the ebb and flow of the seas were correlated with the phases of the moon around which they planned much of their daily activities related to planting crops and fishing.

The shoreline fishponds (loko kuapā and loko pu'uone) and fishtrap (loko 'ume iki) were intimately linked with the changing of the tides. Coupled with the knowledge that most fishes are attracted to currents, 'auwai kai (sluice or channels) were constructed in the walls of the ponds and fishtraps to create currents with each tidal change. In this manner, fish could be harvested from either within the pond or from the ocean depending on which direction the current flowed as the tide changed.

The fishpond mākāhā (sluice grate) and pond walls were designed to allow water circulation from the tides. They functioned like a "filter" to help control water circulation and prevent stagnation and the build-up of sediments, which is critical to maintaining a healthy, balanced fishpond ecosystem.

The shallow depth of Hawaiian fishponds provided the optimal light conditions for plankton and limu growth. Limu and microscopic plankton provide food for the herbivorous fish grown in the pond—the 'ama'ama (mullet) and awa (milkfish). The kia'i loko (fishpond keeper) cared for the pond, just as a farmer tends his pastures for cattle. The kia'i kept the pond walls intact and


mākāhā and ʻauwai kai

checked for excessive limu growth and build-up of pond sediments. If the mats of limu in the pond grew too thick, the limu was thinned by hand. This helped to prevent the depletion of dissolved oxygen in the pond which occurs when large amounts of limu decays. And if the bottom sediments of soil and decayed organic matter got too thick, commoners were called upon to help clear this layer of sediment. The sediments were stirred up and the pond was flushed as the incoming tide circulated in the pond through the mākāhā, and the outgoing tide washed some of the sediment out to sea.

The ancient ʻauwai kai with mākāhā did not have the movable water gates that appeared at the turn of the twentieth century. So the location of the different mākāhā in the early ponds was critical to water circulation. Later, the Chinese and Japanese introduced separate water gates on the ocean side of the mākāhā that allowed them to cut down the rate of water exchange and manipulate the plankton density by closing the gates. As with an aquarium of guppies that lacks filtration, uncirculated fishpond water will start to turn green in a few days, when the phytoplankton grow due to the nutrients (excrement/fertilizer) that build up.

Teaching Suggestions

1. Display a picture of the loko kuapā (from Unit 1, *Loko Iʻa* activity) and ask students to describe how the pond functions. If students have not seen the Kāhea Loko introductory video, have them view it before conducting this activity.

   Discussion Questions

   - What is the purpose of the ʻauwai kai (sluice or channel in the wall) and the mākāhā (sluice grate)?

     (The ʻauwai kai provides a current that attracts fish and during the incoming tide, it allows water to flow into the pond and circulate. During the outgoing tide, the sediments can be flushed out of the pond. The mākāhā, placed between the walls of the ʻauwai kai traps the fish in the pond.)

   - How was it easier to catch fish from a pond than in the open ocean?

     (Fish can be caught easily from a fishpond because the fish are concentrated into a confined area, unlike in the open ocean where the fish are widely dispersed. The fish tend to gather by the ʻauwai kai to swim in the current that is created by the tides flowing through the channel. The fish can be scooped with nets at this location.)

2. Divide the class into groups of "agricultural engineers." Explain to students that a prospective client, Kupuna Kole, is searching for an engineering firm to rebuild her fishpond. The fishpond has not been in use since her father passed away. It is 10 acres large and the pond is filling in with silt that is washed down from the stream that feeds into the pond. She has also been told that the water is becoming stagnant because nutrients are building up and depleting the oxygen in the water. The walls and the mākāhā have fallen apart and she needs to have the pond rebuilt. Kupuna Kole is requesting that each engineering firm present its model and show how the pond will work to circulate water once again and allow the young fish to enter, but the bigger fish to be trapped.

3. Challenge each group of engineers to design and build a kuapā with an ʻauwai kai and a mākāhā. Give each group a pan to build the pond and have students select materials from those provided or acquire additional materials to fit their designs.

4. Once students' ponds are built, give each group two cups of water to add to the pan as low tide. After the water has equalized on both sides of the mākāhā, ask each group to add a few drops of yellow food coloring to the pond side of the model to represent the stagnant water in Kupuna Kole's pond.

5. Give each group a container with two cups of blue-colored water and a meat baster. Ask students to raise and lower the "tide" on the ocean side of their models and report what happens to the stagnant water in their ponds.

6. Provide some small leaves or other lightweight objects to represent large fish and some oregano to represent small fish. Have students add these "fish" to their ponds and create a current to move the fish toward the mākāhā. Do their mākāhā prevent the large fish from escaping? Explain that the adult fish are drawn to the mākāhā on the incoming tide and will actually swim against the current.

7. Ask groups to present their models for Kupuna Kole and describe how their models will work to: a) circulate the water and prevent stagnation, and b) allow small fish to enter and big fish to be retained.

8. Ask students to complete the assessment activity. Have students work individually to create diagrams showing how the circulating water with the changing tide affects water quality and pond life.

   <u>Discussion Questions</u>

   - Why are tidal fluctuations important to a fishpond?
     (They circulate the water between the ocean and the pond, aerating the pond and removing wastes.)
   - How would cementing the rocks of the fishpond wall in place affect the pond?
     (It would keep water from seeping through the walls of the pond, so the only place where the water could circulate and flush nutrients would be through the ʻauwai kai. This could negatively affect water quality in the pond.)
   - How are your models different from a real situation?
     (As always, models are simplified representations of reality. With a real fishpond, you would have the effects of wind and waves on the water and human activities upstream as well as the changing tides.)

Adaptations/Extensions

- Follow this activity with a field trip to a fishpond, and have the students observe the flow of water through the ʻauwai kai. Using small floating objects and a stopwatch, have students calculate the flow rate of the water into or out of the pond.
- Re-visit the K-W-L chart created in Unit 1.

Catch It! Grow It!

- Why and how did Hawaiian fishing technology change from catching fish to growing fish?

Hawai'i DOE Content Standard

Science: Mālama I Ka 'Āina
- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 4-5 Performance Indicators

Grade 4
- Identify agricultural methods used in Hawai'i to increase food production and their impact on humans and the environment.

Grade 5
- Explore how agricultural technology affects humans and the environment.

Key Concept

- Fishing methods evolved in Hawai'i from early techniques of catching fish to the later engineering involved in developing fishponds and growing fish.

Prerequisite

Engineering Ingenuity

Activity at a Glance

Students read a story and role play to demonstrate the different methods of catching fish in old Hawai'i. Students develop an ending for the story and illustrate what they have learned about the evolution of fishing technology.

Time

2 - 3 class periods

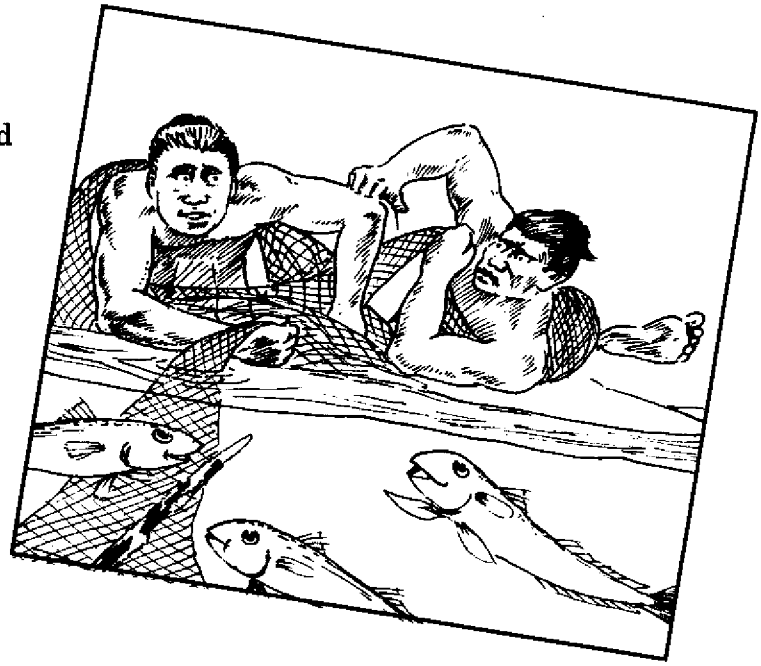
Skills

reading comprehension, drawing, reasoning, writing

Assessment

Students:

- Write a conclusion to the story "The Old White 'Ama'ama Fish."
- Illustrate how fishing technology evolved from catching to growing fish.



Vocabulary

mākāhā – sluice gate or grate
melomelo – stick or club used as a lure, rubbed or wiped with roasted coconut or kukui nut flesh or aromatic leaves
'ama'ama – mullet
'umeke – gourd

Materials

Provided:

- "Old White 'Ama'ama Fish" story
- scenes from the story

Advance Preparation

Make two copies of the section labeled "Scenes." Fold over several times and place in a container.

Teaching Suggestions

1. Read the "Old White 'Ama'ama Fish" story to the class or have students take turns reading parts of the story aloud.

2. Ask students to identify the three different methods of fishing in the story and list the methods on the board:

    - A basket made of 'ie (aerial root of 'ie'ie plant) stocked with vegetables
    - A stick scented with coconut and kukui nut meat used as bait while fishers surrounded the school of fish with a net
    - A human hand holding bait to lure fish while the other hand caught the fish

3. Divide the class into four or five groups of students and have a member from each group draw a scene card from the container.

4. Taking turns, have each group role play a scene to the entire class using only hand and body motions – no speaking allowed. (There may be a duplication of scenes but this will reinforce fishing methods.)

5. Ask students to guess the fishing method demonstrated by each group and continue role playing until each group has had a turn.

6. Discuss the story and the fishing methods with students.

   Discussion Questions

   - Why did early Hawaiians move from catching to growing fish?

     (Ocean fishing was very dangerous, time-consuming and depended a great deal on weather conditions. It took less energy to fish from a pond and weather was less of a factor. When bad weather persisted, commoners often relied on their store of dried fish. Since it was the ali'i that commanded the building of fishponds, his desire to have fresh fish of many different species whenever he wanted could be fulfilled.)

   - Why were fishponds built?

     (It was much easier to grow fish in a contained area than to fish in the open ocean. The loko kuapā were built exclusively for the ali'i. Other types of fishponds and fishtraps could be used by the common people, as permitted by the ali'i.)

7. After the discussion, ask students to complete the "Old White 'Ama'ama Fish" story. Have each student address the following questions in his/her ending to the story:

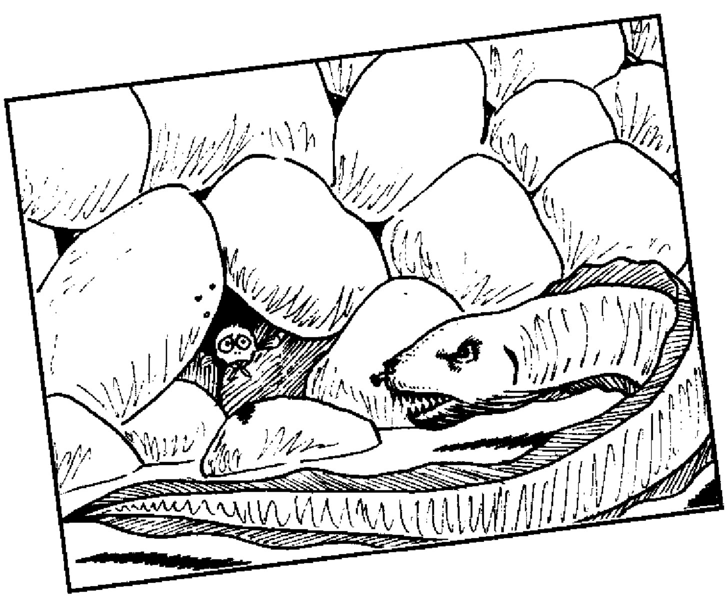
   - What happened to Tūtū?
   - What happened to Kea?
   - Did the fishpond keep them safe from predators? Why or why not?
   - What could you invent for the fishpond that would keep fish contained?

Adaptations/Extensions

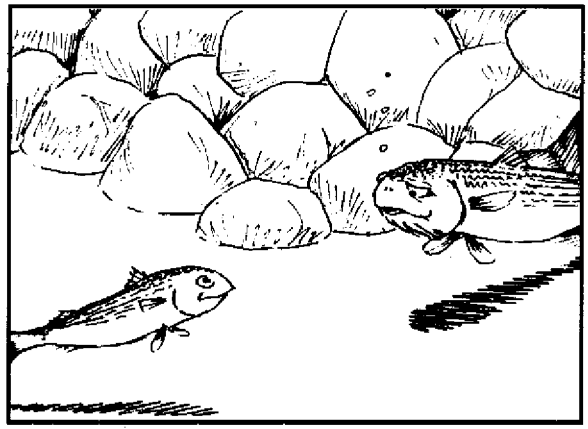
- Research various kinds of fishing methods. Challenge students to recreate fishing tools.

- Have students interview a kupuna (grandparent) who can share fishing stories and experiences. Produce a book authored and illustrated by students.

- Re-visit the K-W-L chart created in Unit 1 and have students add new questions and concepts they have learned.



The Old White ‘Ama‘ama Fish



Relaxing in a crevice in the loko kuapā (fishpond), the old white ‘ama‘ama fish sat with his grandson. “Please, Tūtū, tell me the story about how you got to this fishpond,” Kea begged.

“I’ve told you those stories so many times,” the old white ‘ama‘ama sighed. “I have extra wrinkles to prove it.”

“I don’t get tired hearing them over and over again,” Kea said.

“All right,” Tūtū agreed. “We have some time before your grandmother calls us to eat our limu (seaweed) dinner.”

Tūtū cleared his throat and began. “My brothers and sisters and I were born in the deep, deep blue ocean beyond the reef. We were so small that you could barely see us. We must have been no bigger than the dot on the letter i.

Before we began our journey to the fishpond, mom warned us to be very careful. There were many predators who would love to eat us for lunch! We agreed to look out for other fish we couldn’t trust. And thus began our adventure to the fishpond.

As we were being pushed on the surface of the water by gentle winds and ocean currents, we smelled something really awful! What was that smell and where was it coming from? I noticed that there was a canoe floating above us. It looked like the fishermen in the canoe had been there for several days. Their skin was caked with salt. And their lips were dry and cracked. Poor weather must have kept them from hauling in a catch.

All of a sudden, a huge basket made of ʻie (aerial roots of the ʻieʻie plant) began to slowly lift off the ocean floor. There were kala (surgeon fish) in the basket eating bits of sweet potato and limu. They were so fat and full from eating that they didn't try to escape from the basket.

The fisherman who was hoisting the basket took enough kala for himself and his family and returned the rest of the fish to the ocean unharmed. A few minutes later, my brothers and sisters and I smelled it, again. Wow! It was hauna (an unpleasant odor)! Then, I remembered what my dad had told me about kala. The kala fish eat a lot of limu. When they are caught, and their stomachs are cut open a real stinky smell rises – just like rotten eggs. My brothers and sisters blamed me for the stink smell. But I pretended not to hear them.

Another story I remember is about the melomelo stick. Fishermen use the stick, which is rubbed with coconut and kukui nut meat, to attract fish. They lower the stick into the ocean and when the fish begin to nibble on the end of it, the fishermen surround the fish and catch them with a net.

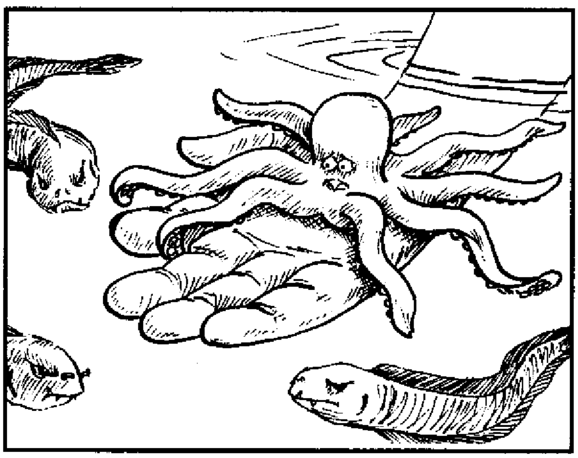
I remember after a huge storm a group of fishermen tried to surround a school of ʻōpelu (mackerel scad). For some reason, the stick got caught in the net and drifted to the bottom of the ocean floor. Meanwhile, the ʻōpelu followed the scent of the melomelo stick. The fishermen tried to go after the ʻōpelu, but they got tangled in their net and looked like a school of ʻōpelu struggling to get free.

My brothers and sisters and I laughed so hard that we almost popped a gill. I've heard that if you look real close at the ʻōpelu, you'll see that he has a permanent grin. Everyone says that the ʻōpelu are remembering the day when the fishermen looked like a bunch of silly fools tangled in their own nets.

One of my favorite stories is when I was nearing the end of my journey. There had been a huge hurricane the previous day. The tsunami had left marine life strewn along the sand.

Many humans were shore fishing. At that time, I was about two inches long – the size of a human pinky finger. I, too, was near the shoreline not too far off from the fishpond.

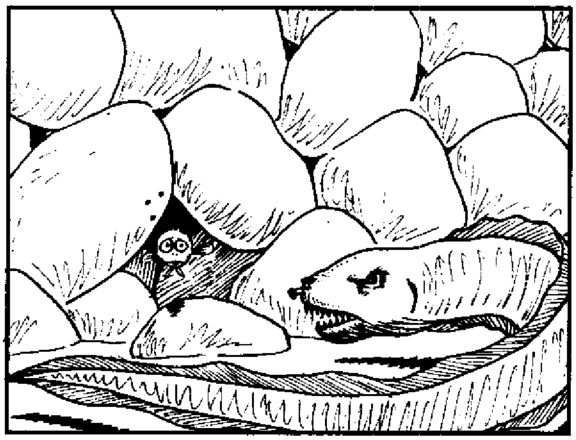
All of a sudden, a human hand descended into the water. In its hand was a baby squid. Within seconds, four baby eels peeped out of their hiding place. The human hand sat motionless in the water. The tentacles of the squid dangled between the fingers inviting the baby eels for a nibble.



As I got closer, I noticed the baby eels cautiously sneaking up on the hand to take a better look. In a split second, another hand snatched up the four baby eels and me along with them. All I remember is being yanked out of the ocean and thrown into an ʻumeke (gourd). There was no water in the gourd so I lay there gasping for air.

As I lay at the bottom twitching, a thumb and an index finger pinched my body and flung me into the air. I was soaring like a bird in the sky until I landed – smack – head first into the ocean. I hit the surface of the water so hard that I bruised my lips. If you look carefully at our ʻamaʻama (mullet) relatives, you will see that we all have a faint color of red on our lips and gills. That's how you know that we are all related.

As soon as I fell into the ocean, I turned toward the fishpond hoping to make my way to safety. But Māmā Pūhi (eel) had just come out of her hole looking for her kids, and she was angry. When I saw her, I knew I was in trouble. I tried to hide behind a patch of limu, but Māmā Pūhi found me. I was stuffed in a hole with nowhere to go. As she slithered towards me baring her sharp teeth, I searched for a way out. All of a sudden.......



Scene Card -1

A huge basket made of ʻie (aerial roots of the ʻieʻie plant) slowly lifted off the ocean floor. There were kala (surgeon fish) in the basket eating bits of sweet potato and limu (seaweed). They were so fat and full from eating that they didn't try to escape from the basket.

The fisherman who was hoisting the basket took enough kala for himself and his family and returned the rest of the fish to the ocean unharmed. A few minutes later, my brothers and sisters and I smelled it, again. Wow! It was hauna (an unpleasant odor)!

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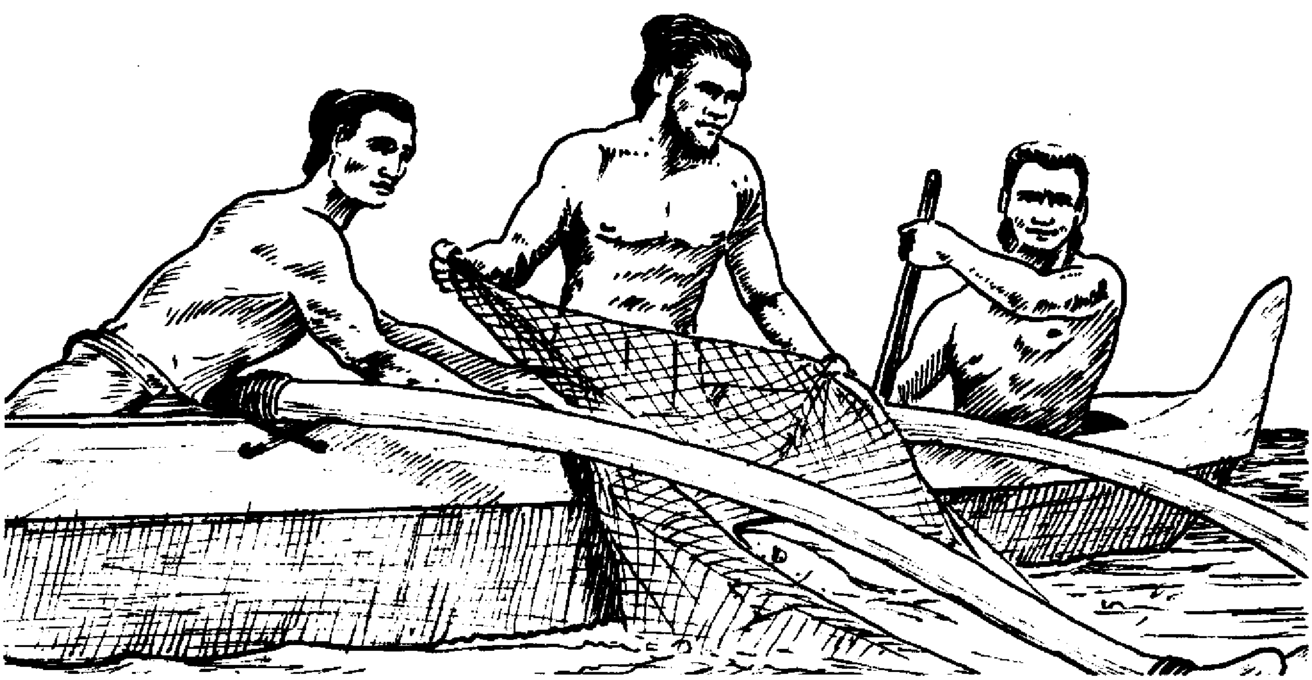


Scene Card - 2

Fishermen use the melomelo stick to attract fish. The stick is rubbed with coconut and kukui nut meat. Then it is lowered into the ocean. When the fish begin to nibble on the stick, the fishermen surround the fish and catch them with a net.

I remember after a huge storm a group of fishermen tried to surround a school of ‘ōpelu (mackerel scad). For some reason, the stick got caught in the net and drifted to the bottom of the ocean floor.

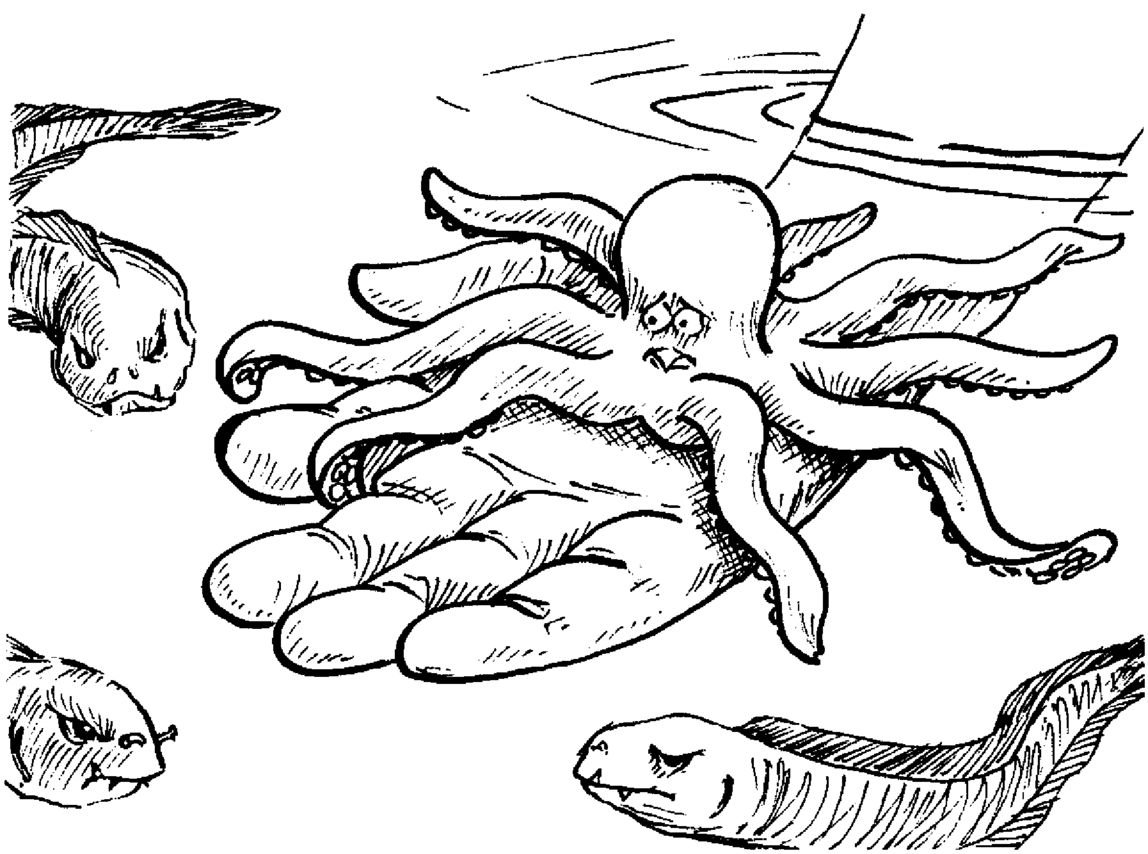
Meanwhile, the ‘ōpelu followed the scent of the melomelo stick. The fishermen tried to go after the ‘ōpelu, but they got tangled in their net and looked like a school of ‘ōpelu struggling to get free.

Scene Card - 3

All of a sudden, a human fist descended into the water. In its hand was a baby squid. Within seconds, four baby eels peeped out of their hiding place. The human hand sat motionless in the water. The tentacles of the squid dangled between the fingers inviting the baby eels for a nibble.

As I got closer, I noticed the baby eels cautiously sneaking up on the hand to take a better look. In a split second, another hand snatched up the four baby eels and me along with them. All I remember is being yanked out of the ocean and thrown into an ‘umeke (gourd). There was no water in the gourd so I lay there gasping for air.

As I lay at the bottom twitching, a thumb and an index finger pinched my body and flung me into the air. I was soaring like a bird in the sky until I landed – smack – head first into the ocean. I hit the surface of the water so hard that I bruised my lips. If you look carefully at our ‘ama’ama (mullet) relatives, you will see that we all have a faint color of red on our lips and gills. That’s how you know that we are all related.



Haku Mele Aloha:

Composing in Hawaiian

- What can traditional Hawaiian fishing practices, mo'olelo (stories), and mele (songs) teach us about values that are important in the Hawaiian culture?

Hawai'i DOE Content Standard

Social Studies: Cultural Systems:

- Students understand culture as a system of beliefs, knowledge and practices shared by a group.

Grades 4 - 5 Performance Indicator

- Interpret and/or illustrate how Hawaiian culture is composed of items (arts, artifacts), ideas (beliefs, values) and behaviors (observable practices that may or may not be related to values and beliefs).

Key Concepts

- Traditional fishing practices, oli (chants), and mo'olelo (stories) express values that are an important part of Hawaiian culture.
- Hawaiian values such as hō'ihi (respect) for others and for the land, kuleana (responsibility) for maintaining a balance between self and society and between human beings and the rest of the universe, are expressed through various forms of protocol and mo'olelo.

Prerequisite

As a note, it is important for any teacher using this activity to consider the level of Hawaiian language use as very basic, and academically inclined in nature. Therefore, the author advises consultation with native speakers prior to adaptation of the activity, and caution in using the format outside of the way it is presented in this unit.

Activity at a Glance

Students read about traditional fishing practices and Hawaiian mo'olelo (story) and describe the values conveyed. Students compose a mele/song entirely in Hawaiian about a place in nature that is significant to them.

Time

3 class periods

Skills

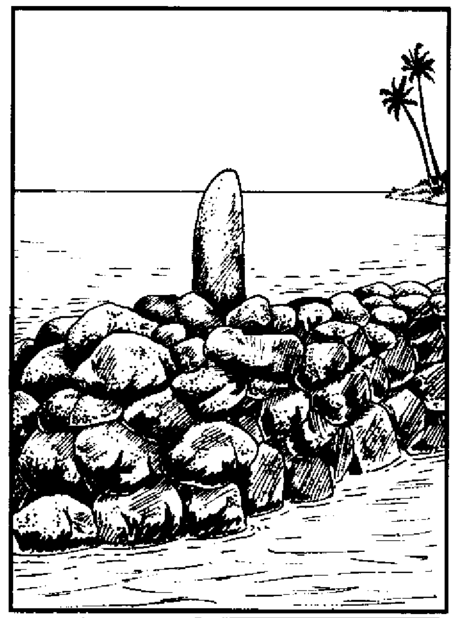
writing composition, reflection

Assessment

Students:
- Write a description of what traditional fishing practices and a Hawaiian moʻolelo (story) reveal about early Hawaiian life and values.
- Compose and share a mele (song) that reveals what a special place in nature means to them.

Vocabulary

koʻa – shrine consisting of circular piles of coral or stone, built along the shore or by ponds or streams, used in ceremonies to make fish multiply; or fishing grounds, usually identified by lining up with marks on shore
oli – chant
mele – song
moʻolelo - story, legend, history, tradition
kuleana – responsibility
hōʻihi – respect
(additional words defined on student activity sheet)


Kū stone

Materials

Provided:
- activity sheets 1 & 2
- student reading - moʻolelo

Needed:
- Hawaiian music (preferably songs with nature themes)
- CD or tape player

Advance Preparation

Compose a mele (song) using the format provided with this activity as an example for students.

Background

Hawaiian culture lives through oral traditions that are passed on through moʻolelo, music, dance, oli and protocol that convey the beliefs, values, and behaviors important in the Hawaiian world view. Fishers offered their first catch at the Kū and Hina stones.

The Kū stone represented Kūʻulakai, the god of fishing, who some say had control over all the other gods of the sea. When he died, one of the gifts he left for his son, Aiʻai, was a magic stone called Kūʻula, which had the power to attract fish. The son traveled about the islands and set up fishing altars upon which to lay two fish from the first catch, one for his father, Kūʻula and one for his mother, Hina (Beckwith, 1970). The Kū stone was placed in an upright position on the eastern side of the fishpond. The Hina stone, representing Kū's wife, lay flat on the western wall of the fishpond. At the fishponds, a small pile of coral or stones was erected where fish were offered in ceremony to Kūʻula by the kahuna (priest). The kahuna would call upon [Kū or] Hina to draw the fish from the sea and into the pond. If the fish tried to escape, they would sense Kū'ula's presence and fear leaving the pond. If they tried to make their way over the wall of the pond, the stones – representing men – would prevent them from escaping (Wyban, 1992).

Every member of traditional Hawaiian society composed chants, poems, and songs. It was typical for a person to have a name chant composed for him or herself at birth. It was everyday protocol for a passerby to chant out to someone for permission to enter one's home or to enter a special place.

The following passage describes how loina (Hawaiian protocol) was part of everyday life for the Hawaiian people.

What is loina (Hawaiian protocol)?

It is the right behavior conducted at the appropriate time by the proper people, presented to the correct recipients, toward a positive and significant end.

Protocol almost always involves words, presented usually in the form of oli or chant. Oli takes the power of words, themselves recognized as highly significant in Hawaiian and in many other cultures, and extends that power of words to a higher level that fulfills several functions:

1. It **focuses the attention** of all participants to the task at hand.
2. It **evokes respect** in the form of silence and attention on the part of the recipients.
3. It **prepares the participants** to engage seriously in what will follow.
4. It **initiates a set of responses** from those who know the protocol, and therefore sets into action a social process that unifies not only those who conduct the protocol but also all who are involved.
5. It **transforms the mood** from the mundane and ordinary into something deeper and more important.
6. It **links all participants together** and consolidates them into a unit.
7. It **links the participants to their surroundings** via an enhanced sense of place.
8. It **expresses and confirms a living and vital Hawaiian culture**, making each person a bit more appreciative of and more connected to these islands that we call home.

Protocol suggests that training and practice is involved, and indeed this is so. The practice is a traditional and oral one, with teachers passing the proper and expected behaviors to their students. Students and teachers in turn practice protocol with each other and develop comfort at conducting themselves in very specific ways that often demand exactly the right words and actions in a prescribed sequence.

Proper behavior and words are highly dependent on the situation. For example, the protocol for greeting a person of significance is different from the protocol of entry to a significant site and different from the protocol for presentation of an offering or gift. Whatever the situation, protocol is based on a foundation of values that are important to everyone, regardless of their ancestry and upbringing. These are fundamentals such as respect for others and for the land, an attitude of sharing and responsibility for maintaining a balance between self and society and between human beings and the rest of the universe.

Written by: Sam Gon III, Ph.D., Director of Science at the Nature Conservancy of Hawai'i and Chanter with Kumu John Keolamaka'āinana Lake

Teaching Suggestions

1. Begin the day with Hawaiian music playing (preferably a song with a nature theme). Discuss students' reactions to the music. Which values are evident in the mele (song)?

2. Distribute the first activity sheet and ask students to read and discuss it.

   Discussion Questions

   - What was the significance of the Kū stone and the Hina stone at the fishpond? *(The kahuna would call upon Kū or Hina to draw fish from the sea into the pond.)*
   - In the mo'olelo, what is the ko'a and how is it used? *(Ko'a are fishing shrines made of coral or stones. Offerings are made to thank the gods for the fish that are received or to ask that the gods help the fish multiply and become plentiful.)*
   - Which values are evident in traditional fishing practices? *(kuleana [responsibility], laulima [working together], hō'ihi [respect], taking only what you need)*

3. Distribute the student reading (mo'olelo) and have students take turns reading the text aloud. Discuss their reactions to the mo'olelo.

4. Ask each student to write a summary of what the story means to him or her. Ask them to describe what traditional fishing practices and the mo'olelo reveal about early Hawaiian life and values.

5. Have students share their ideas about the readings and discuss them with the class.

   Discussion Questions

   - What do traditional fishing practices and the mo'olelo reveal about early Hawaiian life and values?
   - Why are the cultural traditions and practices important to preserve?
   - What other cultural traditions are important in your life and how are they preserved?

6. Distribute the second activity sheet to students and explain how to utilize the format to create a mele. Share your composition as an example. Challenge students to compose their own mele about a special place in nature.

7. Ask students to work in pairs and share their mele (song) with a partner.

8. Have students complete the assessment activities and work together (laulima) with their classmates and a kupuna to write a mele or an oli that they can share with others when the class visits the fishpond. The oli (chant) can be used as greeting to the staff at the fishpond.

Adaptations/Extensions

- Combine individual student compositions to create a song. Experiment with ancient and modern rhythms and compose a beat to students' compilation.

- Ask a hula teacher or your school's kupuna or makua to help students compose hula motions to convey the meaning and imagery of their mele. Help students develop costumes and share the hula with other classes. Students can perform their hulas for cultural protocol, assessment purposes, or for special school events that allow for them to exhibit their work.

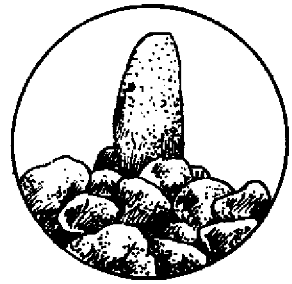
- Have students prepare a hoʻokupu (gift-giving) for their trip to the fishpond. It is customary to show appreciation by presenting hosts with a gift. The gift may include a simple illustration from the students or something more lavish. Idea: Ask each student to bring a fruit, vegetable or small plant from their home. The item they bring should be something personal either a fresh food produce they enjoy eating or a plant grown in their yard. Combine these items, making a gift basket, which can be presented to your hosts.

- Re-visit the K-W-L chart from Unit 1 and add students' new ideas and questions they wish to pursue.

References

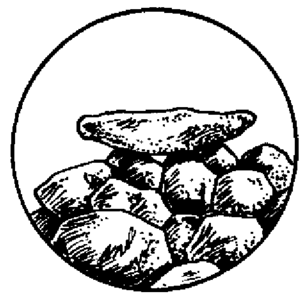
Beckwith, Martha. 1970. *Hawaiian Mythology.* University of Hawaiʻi Press. Honolulu, HI.

Student Activity Sheet 1



Hawaiian fishponds and fishing practices help us to learn about early Hawaiian life. In the old days at the fishpond, an upright Kū stone was placed on the eastern wall of the pond. A stone for the goddess Hina was placed on the western side. The god Kū had many forms. One form was the god of fishing, Kū'ulakai, which means "an abundance from the sea" or "red Kū of the sea." Hawaiians offered prayers to Kū'ulakai, the fish god, by facing to the east at early morning. Prayers to Hina were offered facing to the west.

Kū stone (above) and Hina stone (below)



Legend has it that if the prayers to Kū were not answered, the people would plead to the goddess Hina. They prayed to her to influence Kū and make the fish plentiful for the people. The first fish caught was offered to Kū'ulakai. Part of the first taro or sweet potato harvest was also offered to the gods. Limu kala lei were offered to Kū'ulakai at the ko'a (fishing shrine). This practice continues today by anyone grateful for the gifts that come from the sea.

Today we continue to express cultural values through oli (chants), mele (songs), and mo'olelo (stories). Expressing values, such as hō'ihi (respect) and kuleana (responsibility), is an important part of Hawaiian protocol. The mele and mo'olelo are passed down to help us appreciate the Hawaiian culture and learn proper actions toward others and our environment.

Activities

1. Read the mo'olelo about a woman who caught he'e (squid or octopus) for the ali'i (chief).

2. On the reverse side of this page:
   - Write a summary of the values that the story teaches.
   - Describe what the story means to you.
   - Describe Hawaiian fishing practices related to the ko'a (fishing shrine).

3. Use the activity sheet provided to help you write a mele that expresses how you feel about a place in nature.

Student Activity Sheet 2

Make your own mele/song by inserting the appropriate words from the papa ʻōlelo/ vocabulary categories A, B, C, D, E into the format below.

1. Identify the place (A) and the name of the place.
2. Briefly describe a physical feature of the place (A and B).
3. Briefly describe an experience (ʻike-to see) of the place (B).
4. Tell why the place is special to you (C) and the place name (D).
5. Give the name of a person (E) for whom this mele/song is written.

1. (A) ______________________ ʻo (D) ______________________.

2. (A) ______________________ (B) ______________________.

3. ʻIke i (B) ______________________.

4. (C) ______________________ ʻia ʻoe i (D) ______________________.

5. He mele kēia na (E) ______________________.

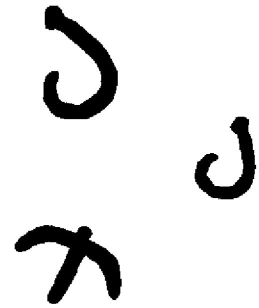
Papa ʻŌlelo/Vocabulary

A	B	C
kaulana - famous	ka ʻāina - land	hoʻokipa - to welcome
hanohano - glorious	ka uka - uplands	kono - invite
nani - beautiful	ka wailele - waterfall	mālama - care for
uluwehi - lush, verdant	ke kahawai - stream	ʻume - attract
waiwai - valuable	ke kula - plains, field	hoʻopili - to come together
maloʻo - dry	ke kahakai - beach	aloha - love, affection, greeting
pulu - wet	ke kai - sea	hoʻolu - to make comfortable
ʻoluʻolu - pleasant	ka moana - ocean	hoʻohauʻoli - to make happy
kilakila - majestic	ka lae - headland	kāhea - call out
kiʻekiʻe - high	ka nahele - forest	hoʻopaʻa - to secure

D: ______________________________
(name of place you are writing about)

E: ______________________________
(name of person for whom you are writing this)

Student Reading - Mo'olelo



There lived a woman on O'ahu that was noted for her skill in catching the he'e (octopus or squid). One day, a chief planned for a large lū'au (feast) that would require a large amount of he'e. The woman was summoned by the chief and told that he would allow her to catch he'e in his ahupua'a for this purpose.

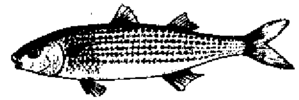
The next day the woman brought her daughter with her and set out to catch what she needed. Before she entered into the water, an elderly man met her at the shore. He carefully reminded her that she could only catch a certain amount of he'e. He told her that once she had gotten what she was allowed, she should return home with her catch and not to stop for anything.

While fishing, she caught all that she was allowed to catch but instead of returning home as instructed, she continued to fish. She soon found that she had more than she could handle. She called her daughter and instructed her to go home with half of the catch while the woman went home with the other half. While her daughter made her way to the shore, the woman caught a glimpse of a huge he'e and she proceeded to try and catch it. At that moment, a shark appeared and bit off the woman's legs. The daughter heard her mother screaming and tried to rescue the woman but it was too late. She died from the severity of the shark attack.

When the people retrieved what was left of her body, they noticed a single deep gash on her right arm. The people immediately recognized the discrete cut as having been made by the teeth of a shark that was known to guard the area. After this incident, the people named the area Paumalū, which is an area that includes Sunset Beach on the North Shore of O'ahu and means "taken illegally."

Source: Manu, M. et al. 1992. *Hawaiian Fishing Traditions*. Kalamakū Press. Honolulu, HI.

Unit 3 at a Glance



Grades 6 - 8

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: Historical Empathy Develop historical empathy by analyzing the past on its own terms; not judging it solely by present-day norms and values.	**3D**. What do legends reveal about values that were important to early Hawaiians, and how did these values apply to the maintenance and care of fishponds? **Activity: *Whose Kuleana Is It Anyway?***	• Hawaiian legends are like windows to the past, shedding light on cultural values and how those values shaped human interactions with one another and their environment. • The maintenance of fishponds was essential to their productivity. Early Hawaiians maintained their fishponds by keeping the pond walls intact and by removing excess limu (algae) growth and bottom sediments.	Students select values from the story *Kūʻula: God of Fishermen* and write a paper (at least one page), from the perspective of an aliʻi (chief) that describes: • how the aliʻi would respond to a natural disaster such as a tsunami or volcanic eruption that severely damaged the fishpond; and • the value(s) that are important in interacting with others and the environment.
Social Studies: Change, Continuity and Causality Identify possible causal relationships in historical chronologies. Offer fact-based explanations for change and continuity in history.	**3E.** What has caused the decline of Hawaiian fishponds over time? **Activity: *Fishpond Fall***	• Many factors contributed to the decline of Hawaiian fishponds, including battles, the introduction of diseases, the sandalwood trade, the Great Mahele, natural disasters, land development, and changes from a subsistence to a market economy.	Students: • Complete a timeline that shows the chronology of events that contributed to the decline of fishponds. • Create a drawing or write a summary of how key people, events and/or ideas affected fishponds over time.

Culminating Activity

Students select a time period or periods from the timeline they create in this unit and conduct research to determine how key people, events and/or ideas in that period contributed to the decline of fishponds. Students complete a project to summarize what they have discovered and present their information to the class. Projects may take the form of:

- an imaginative moʻolelo (story), mele (song), or oli (chant) about events in one or more time periods
- a diorama showing the past and present for a specific fishpond
- a mural depicting the decline of fishponds over a time period
- a research report

Note: Make available the historical account cards from the *Fishpond Fall* activity and refer students to references listed at the end of the lesson. Ask students to cite each of the references they use to complete their projects. Review criteria for assessing students' work (see sample rubric).

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia Exceeds Standard	Mākaukau Meets Standard	'Ano Mākaukau (Almost at Standard)	Mākaukau 'Ole (Below Standard)
Social Studies: Change, Continuity and Causality Select key people, events and/ or ideas in an era(s). Organize the key people, events and/or ideas into a chronology. ***Points*** _____	Project clearly shows key people, events and/or ideas in an organized chronology. Chronology includes additional ideas beyond what was presented in the unit.	Project clearly shows key people, events and/ or ideas in an organized chronology.	Project lacks organization and focus to clearly show key people, events and/or ideas in a chronology.	Project does not show key people, events, and/or ideas in a chronology.
Using the chronology, explain how key people, events and/or ideas changed or stayed the same over time. ***Points*** _____	Project clearly explains how key people, events, and/or ideas in a time period led to the decline of fishponds. Explanation is in-depth and shows evidence of critical thinking.	Project clearly explains how key people, events, and/or ideas in a time period led to the decline of fishponds; shows evidence of critical thinking.	Project only partially explains how key people, events, and/ or ideas in a time period led to the decline of fishponds. More information is needed.	Project does not explain how key people, events, and/ or ideas in a time period led to the decline of fishponds.
Use of References ***Points*** _____	References used are correctly cited, extensive and varied; level of research is beyond expectations.	References used are appropriate for task and correctly cited.	References are not cited correctly or there is minimal use of references.	References are not cited in work.
Language Arts: Oral Communication Convention and Skills: Uses pace, volume, stress, enunciation, and pronunciation to communicate and for effect.Uses speech patterns that are appropriate to the listeners and situation. ***Points***____	Dynamic presentation; well prepared; shows mastery of conventions—uses pacing, volume, stress, enunciation and pronunciation to communicate effectively.	Effective presentation; shows mastery of conventions; well prepared; pacing, volume, enunciation and pronunciation are appropriate to audience.	Presentation needs prompting; fluency and conventions are lacking	Presentation lacks appropriate use of conventions, which leads to poor communication.

I NOTICED:

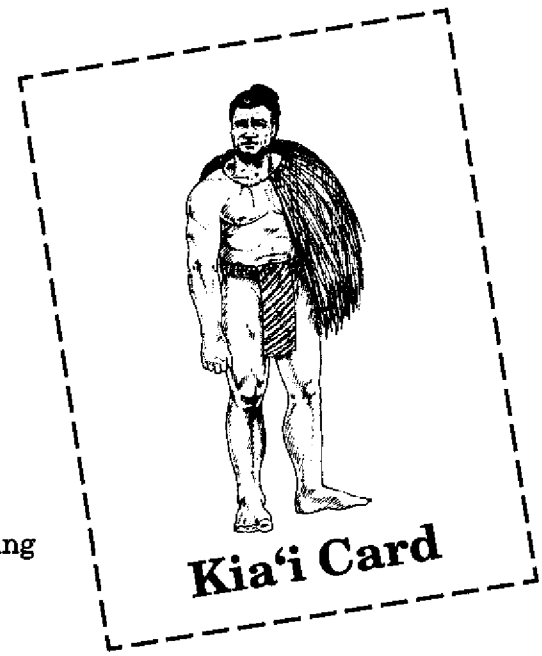
Whose Kuleana Is It Anyway?

- What do legends reveal about values that were important to early Hawaiians, and how did these values apply to the maintenance and care of fishponds?

Hawaiʻi DOE Content Standard

Social Studies: Historical Empathy

- Students learn to judge the past on its own terms and use that knowledge to understand present day issues, problems, and decision making.



Grades 6 – 8 Performance Indicators

Using historical evidence, students:

- Identify the values and norms of a specific era.
- Explain the feelings, thoughts and experiences of the people of the specific era.

Key Concepts

- Hawaiian legends are like windows to the past, shedding light on cultural values and how those values shaped human interactions with one another and their environment.

- The maintenance of fishponds was essential to their productivity. Early Hawaiians maintained their fishponds by keeping the pond walls intact and by removing excess limu (algae) growth and bottom sediments.

Prerequisites

Project Kāhea Loko: Call of the Pond Video;
Kai Moku: Turn of the Tide, Unit 2

Activity at a Glance

Students read a legend and play a board game to discover how Hawaiians maintained their fishponds and which values were important in human interactions with one another and their environment.

Time

3 - 4 class periods

Skills

critical thinking, communication, writing, reasoning

Assessment

Students select values from the story *Kū'ula: God of Fishermen* and write a summary (at least one page), from the perspective of an ali'i (chief) that describes:
- how the ali'i would respond to a natural disaster, such as a tsunami or volcanic eruption, that severely damaged the fishpond; and
- the value(s) that are important in interacting with others and the environment.

Vocabulary

'ōlelo no'eau – Hawaiian proverbs; wise sayings
kuleana – responsibility, concern
konohiki – supervisor of an ahupua'a who controlled the land, water, and fishing rights
kia'i loko – (pond caretaker)

Materials

Needed
- 2 dice
- 12 game pieces (use shells, colored buttons, pebbles, or such)

Provided
- game board
- set of kuleana cards
- set of kia'i cards
- set of loko i'a cards
- student reading: *Kū'ula: God of Fishermen*

Advance Preparation

Make two copies of the kuleana cards and kia'i cards and cut them out. Make six copies of the loko i'a cards and cut them out. If possible, laminate all cards. Make two copies of each gameboard sheet and tape the two pages together to make two gameboards.

Background

The maintenance of fishponds was essential to their productivity. Early Hawaiians maintained their fishponds by keeping the pond walls intact and by removing excess limu (algae) growth and bottom sediments. When the bottom sediments of soil and decayed organic matter got too thick, the konohiki or the kia'i loko (pond caretaker) summoned the commoners. As tenants of the land, men, women, and children owed certain responsibilities to their ali'i. Often, this was the only time that commoners might have a share of certain fishes and seaweeds living in the ponds of the ali'i. Mullet were strictly kapu to the commoners, but "people cleaning the fishponds also used their hands to grope about and catch fish whenever they could. The catch was then the property of the commoner and not of the konohiki or chief" (Kikuchi, 1973). The commoners would stir up the sediment layer and scrape the mud and silt toward the 'auwai kai to be flushed out with the ebbing of the tide. The 'limu breakers' would break loose the algal mats and filamentous algae and twist it into the shape of a ring. Then the broken off limu was pressed down like a dish, and all the fish that were caught in this limu dish were for the limu breakers (Summers, 1964). This regular pond maintenance was necessary to prevent the depletion of dissolved oxygen, which can occur when large amounts of organic matter are left to decay in the pond.

Kū'ulakai – the god of fishing

The mo'olelo provided with this activity introduces students to the legend of Kū'ulakai, the god of fishing. The Hawaiian values in the story are associated with conserving fish and having a fair and generous distribution of the fish catch. Mo'olelo, oli (chants), 'ōlelo no'eau (proverbs) and mele (song) are an expression of Hawaiian oral traditions. Communication was often in the form of metaphors that revealed Hawaiian intellect, humor, wisdom and dignity. Today these oral traditions reveal the thoughts and feelings of the early Hawaiian, providing a glimpse into the past of a people connected to their environment. The 'ōlelo no'eau and mo'olelo provide a basis for understanding the essence and origins of traditional Hawaiian values.

Teaching Suggestions

1. Conduct a class discussion to review what students learned in the prerequisite lesson, *Kai Moku: Turn of the Tide.*

   Discussion Questions

   - What would happen if there was no circulation of water in a fishpond?
     (The water would become stagnant and bottom sediments would build up, leading to loss of dissolved oxygen that pond animals need.)
   - What do you think the kia'i loko (pond caretaker) did to prevent the pond water from becoming stagnant?
     (See Background. Accept any ideas; answers will be revealed in the game that students play.)
   - Which values are important in caring for the environment?
     (Define values as a set of standards or beliefs practiced by a group of people and discuss the importance of mālama [caring], laulima [cooperation], kuleana [responsibility], and other ideas that students may have.)

2. Distribute the student reading, *Kū'ula: God of Fishermen* and ask students to look for the values expressed in the mo'olelo. As they read, have students make a list of the values the characters exhibit in the story.

3. As a class, discuss the story and list the values on the board.

4. Introduce the game, "Whose Kuleana Is It Anyway?" and explain that the objective of the game is to discover important values and practices related to fishing and fishponds in early Hawai'i.

5. Divide the class into two groups, one group for each gameboard. Within each group, have students form pairs to represent an ʻohana (family). There should be six ʻohana per group for a total of 12 players per gameboard.

6. Explain that each group lives in an ahupuaʻa (land division) in early Hawaiʻi. Each ʻohana has a kuleana (responsibility) to ensure that the community fishponds and particularly the fishponds of the aliʻi are properly cared for and maintained.

7. Review the game instructions (Unit 3 Page 41) and play the game.

8. After students have played the game, have a class discussion:

   - Which values are important in the care and maintenance of fishponds? Why?
   - What values would you expect to see in a leader today? Why?
   - Are these same values evident in leaders of the past?

9. Have each student select values from the *Kūʻula: God of Fishermen* reading and complete the assessment activity.

Adaptations/Extensions

- Ask students to write a summary describing how the value(s) they've selected are incorporated into their day-to-day interactions with their classmates and/or family members.

- Have students select an ʻōlelo noʻeau (proverb) provided on the following page and describe how it could apply to Hawaiian interactions with the fishpond environment.

- Ask students to write their own ʻōlelo noʻeau and translate it.

- Have students choose a value and write their own moʻolelo (story).

- Have students create their own kiaʻi cards and play the "Whose Kuleana Is It Anyway?" game again.

References

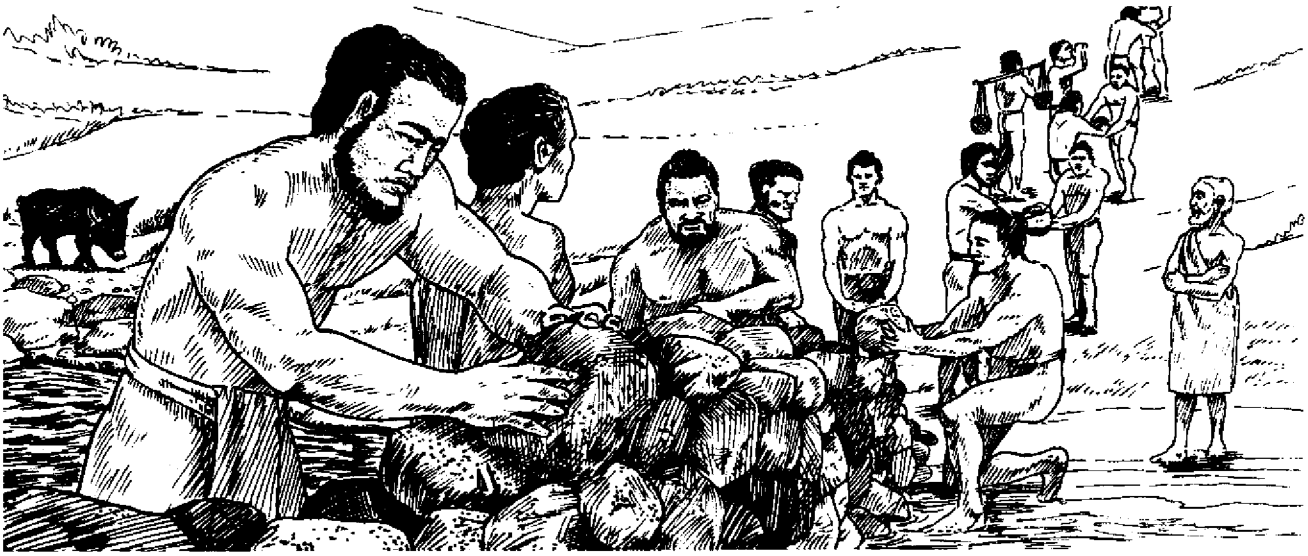
Kikuchi, William K. 1973. *Hawaiian Aquacultural System*. The University of Arizona, Ph.D. Dissertation, Anthropology. UMI Dissertation Services. Ann Arbor, MI.

Pukui, Mary Kawena and Samuel H. Elbert. 1986. *Hawaiian Dictionary*. University of Hawaiʻi Press. Honolulu, HI.

Pukui, Mary Kawena. 1983. *ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings*. Bishop Museum Press. Honolulu, HI.

Summers, Catherine C. 1964. *Hawaiian Archaeology: Hawaiian Fishponds*. Bishop Museum Press. Honolulu, HI.

ʻŌlelo Noʻeau (Proverbs)



- Hoʻokāhi ka ʻilau like ana.
  Wield the paddles together.
  Meaning: Work together.

- He aliʻi ka ʻāina; he kauwā ke kanaka.
  The land is a chief; man is its servant.
  Meaning: Land has no need for man, but man needs the land and works it for a livelihood.

- E ʻōpū aliʻi.
  Have the heart of a chief.
  Meaning: Have the kindness, generosity, and even temper of a chief.

- Hoʻokāhi no lā o ka malihini.
  A stranger only for a day.
  Meaning: After the first day as a guest, one must help with the work.

- Aloha kekahi i kekahi.
  Love one another.

- ʻAʻohe hua o ka maiʻa i ka lā hoʻokāhi.
  No task is too big when done together by all.

Student Reading

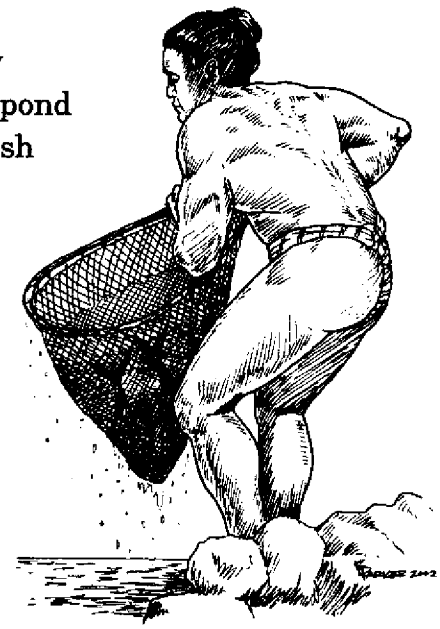
Kūʻula: God of Fishermen

Kūʻula lived with Hina, his wife, and ʻAiʻai, their son, in Hāna on Maui. Kūʻula was a fisherman of great wisdom and power. He walled a fishpond on the edge of the sea and stocked it with all sorts of fish. Nearby he built a shrine where he made his offerings. Because of his wisdom and his reverence for the gods, Kūʻula could always catch the fish he wanted. He knew the best way to catch each kind and when he prayed, fish came at once to his hook, net or basket. When his neighbors had no luck fishing, Kūʻula shared with them.

These neighbors talked of Kūʻula's wisdom and his kindness. They boasted of his success in fishing until his fame went all about the island. The high chief of Maui, hearing of Kūʻula's skill, made him head fisherman. For many years Kūʻula served the chief both faithfully and well.

But about the time that ʻAiʻai, the son, reached manhood, trouble began. Fish disappeared from the well-stocked pond so that it was no longer easy to supply the chief. Kūʻula was troubled and kept constant watch trying to discover what was destroying his fish.

One night, just as the morning star arose, Kūʻula opened his pond gate. The tide was coming in and he prayed that fish might come with it. At daybreak he stood on a rocky point above the pond watching the rush of water. There he was joined by a neighbor. "Look!" Kūʻula exclaimed. "There comes the one who destroys my fish!" The two saw an enormous eel enter the gate then disappear in the pond.

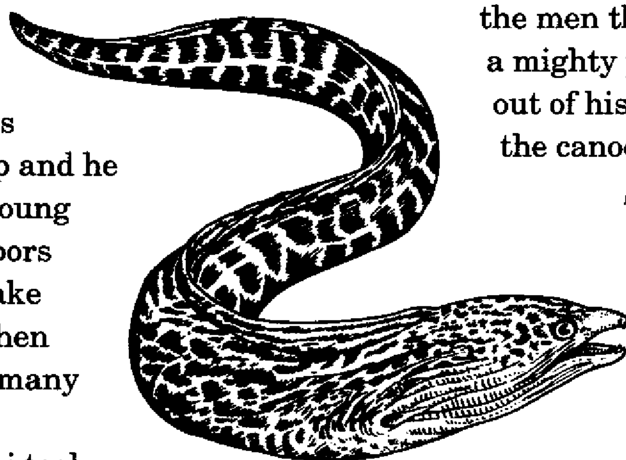


"That must be the great eel of Molokaʻi," the neighbor whispered. "I have heard of such an eel which lives in a cave on the windward side of that island and is worshiped by the people. They say he destroyed a man-eating shark. This powerful eel caused rocks to fall on the shore and kill him. Then the eel made his home in the cave opened by those falling rocks."

"Let him fish about his own island," answered Kūʻula. "If he comes here day after day to steal my fish he shall die."

"But he is worshiped by the men of Molokaʻi," the neighbor repeated. "They will be angry if you kill him."

"Let them be angry! If that eel comes day after day to eat my fish he shall die." Kūʻula went home to talk the matter over with his wife. Finally he said to his son, "ʻAiʻai, you are a man. Here is our enemy, a giant eel. Day after day he comes. Day after day our pond grows empty of fish. Let this be your work, my son, to rid us of our enemy."



ʻAiʻai was glad. His father needed his help and he should have it! The young man called the neighbors and asked them to make ropes of hau bark. When the ropes were ready many canoes put out to sea. Besides the ropes ʻAiʻai took two heavy stones and his father's sacred hook.

The young man had prayed earnestly and watched the eel. Now, pointing silently, he directed the canoes. He was sure the eel hid in a cave in the ocean floor. He found this place by landmarks on the shore. When the canoes reached the place ʻAiʻai chewed kukui nut and spat out the juice. Looking into the water quieted by the oil he plainly saw the cave mouth. He seized one of his heavy stones and jumped. The stone's weight took him to the bottom. As he came near the cave mouth he noticed fish swimming about in a frightened way. They know the eel hides in that cave, the young man thought. He rose to the surface and climbed into the canoe.

Now the hau ropes were unrolled. To one end ʻAiʻai fastened a stick and on the stick the sacred hook baited with coconut. The ropes were passed to other canoes for, once the eel was hooked, the strength of many would be needed to pull him ashore. By signs ʻAiʻai showed his neighbors what to do. Then, praying, he took his second weight and dived. He hooked the sleepy eel and jerked the line to show the men that he was ready. With a mighty pull they lifted the eel out of his cave. ʻAiʻai reached the canoe and scrambled in.

The men dug their paddles into the sea trying to hold firm against the mighty thrashing of the eel. ʻAiʻai directed and, pulling together, at last they got the great fish into shallow water. They tried to kill it but it thrashed about, snapping angry jaws so that they could not strike it with their spears. Then ʻAiʻai seized a huge rock and threw it at the eel. Still the great body coiled angrily and the jaws snapped. The young man threw another rock. He threw a third and the eel lay still – dead at last.

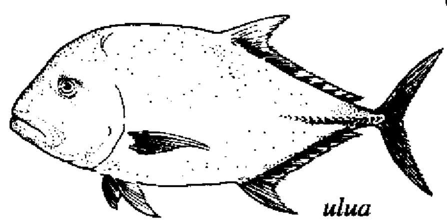
On Molokaʻi the caretaker was troubled because the eel he worshiped no longer came for food and ʻawa. One night the spirit of the eel came to this caretaker in a dream. "I have been killed," he said. "Men of Hāna, Maui, have killed my body."

Angered, the man went to Maui. There he was shown the jaws of the dead eel. "See there!" the men told him proudly. "See those rocks, washed by those waves. Those were the jaws of a great eel. He robbed the fish pond of Kūʻula. ʻAiʻai, Kūʻula's son, hooked the robber and we his neighbors, pulling with all our strength, stranded the eel. Here ʻAiʻai killed him and his jaws have turned to stone. Over there is his backbone. That too is stone. See what a giant monster that eel was!"


kiaʻi (pond caretaker)

"Yes, I see," the man answered quietly but to himself he added, ʻAiʻai and Kūʻula shall die because of this wicked deed.

The caretaker made his plans. He became a servant of the high chief and served so well that the ruler trusted him. One day, he came to Kūʻula asking him for fish. "Fish are still scarce," Kūʻula told him. "Since that great eel robbed my pond, fish have been hard to get. The chief will understand. Take this ulua and tell him to have his servants cut off its head and cook it in the imu. Let its flesh be cut up, salted and dried in the sun."


ulua

The man from Molokaʻi took the ulua and returned to his chief. His chance had come to punish ʻAiʻai and Kūʻula! "O heavenly one," he said. "Kūʻula, your fisherman, sends only this one fish. These are his words, "Tell the high chief to have his servants cut off the chief's head and cook it in the imu. Let them cut up the chief's flesh, salt it and dry it in the sun."

Hearing these words the high chief became angry. He forgot Kūʻula's years of faithful service and believed the lies of his new servant. "Kūʻula shall die!" he shouted and made the man from Molokaʻi his messenger. "Tell my overseers," he commanded, "to have my people gather wood. Let this be piled about the houses of Kūʻula and let him, his wife and son perish in flames." Gladly that man took the message.

ʻAiʻai saw the men bringing wood. "What is it for?" he asked them. But the men did not know. They obeyed the overseer and asked no questions.

"Father," said ʻAiʻai, "men are gathering much wood. See where they pile it! What can it be for?"

"For our death," answered the wise Kūʻula. "The servant has changed my words to lies. The chief is angry and has ordered that we three be put to death."

"There is time to escape," said ʻAiʻai.

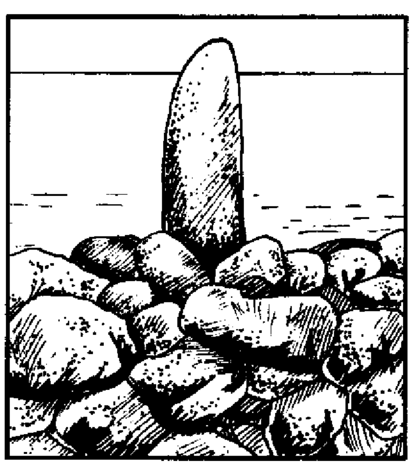
"Yes," his father answered, "there is time. Men will bind us three and start the fire. When the smoke blows seaward my spirit and that of Hina will escape into the sea. There we shall live as fish. When the smoke blows up the mountain slope run with it, my son. Find a cave for your home. When you have need of fish set up this little image of stone, make offering and pray. Your mother and I will hear your prayers. We shall teach you many ways of fishing. We shall send fish to your hooks and baskets. Take my sacred hooks: the one you used to catch the eel, my aku hook of pearl and my cowry for catching heʻe. All my wisdom I give to you my son, my wisdom and my power. You shall live and become a teacher of fishing throughout Hawaiʻi-nei. Show men good fishing grounds and teach them to worship and make offering."

Just at nightfall men rushed into Kūʻula's sleeping house. They seized Kūʻula, Hina and ʻAiʻai, bound their hands behind them and tied each to a post of the house. The Molokaʻi man was with them, directing them. "Now block the doorway!" The three heard his command. "Pile the wood close to the house and start the fire."

Kūʻula, in his wisdom, knew that some did not obey these words. The neighbors with whom he had shared fish were not piling wood nor starting fire. They stood weeping, longing to help the three.

But Kūʻula and his family did not need their help. Before the fire was lighted the cords that bound them had fallen off. As the fire crackled and the thatch burst into flames the smoke blew seaward and with that smoke, invisible, the spirits of Hina and Kūʻula found safety in the sea.

The roof blazed and smoke blew up the mountainside. In that smoke ʻAiʻai escaped. Then flames leapt out and destroyed the man of Molokaʻi and his helpers. But the neighbors who had refused to bind the three and start the fire – those neighbors were unharmed.



ʻAiʻai found a cave which he made his home. Next day as he went out in search of food he met some boys who were practicing with bow and arrows. He made friends with them and one of the boys invited ʻAiʻai to his upland home. There the young man lived for some time unrecognized, helping the farmer with his work.

Because of the cruelty of chief and men, Kūʻula and Hina took away fish, shellfish, even seaweed. The high chief could not understand why no seafood was set before him and commanded men to fish for hīnālea (wrasse) but none were caught.

One day ʻAiʻai asked the farmer, "Each day you and your wife and son go to the beach. Each day you come home empty-handed. Why do you go?"

"We obey our chief's command," the farmer answered. "Each day we go to catch hīnālea but the sea is empty."

Then ʻAiʻai told those people to gather beach-morning-glory vines and taught them to make baskets. "Now come with me," he said and led them to a rocky place above the beach. There he placed the stone image his father had given him. "This is your kū'ula," he told his friends. "Make offering and pray. Then set your baskets in that pool." He showed them how to weight each one with stones.

As they stood watching they saw fish gather about the baskets. "They have returned," the people whispered. "The fish are here once more."

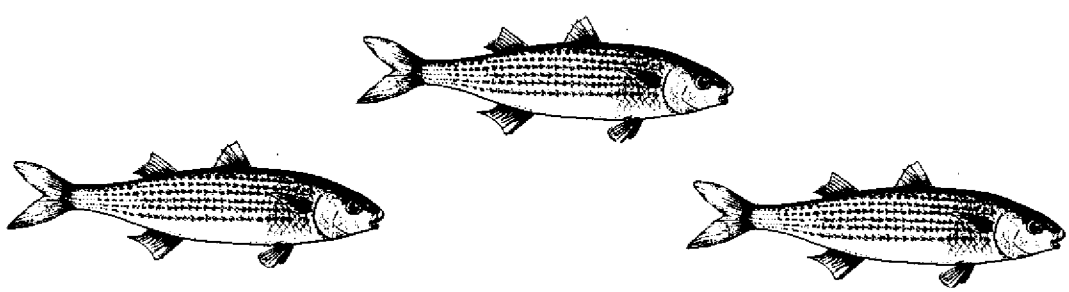
"Call your relatives and friends," said "Ai'ai. "There is fish enough for all."

That night there was feasting in the village by the sea. "Kū'ula, our good neighbor, is not dead," the people said. "We shall pray to the image he has given us. We shall make offering of the first fish caught. Our old neighbor will bring us food as he did when he lived among us as a man."

A runner came from the upland. "The high chief is dead," he told the people. "He tried to eat the hīnālea and died." The people understood that the fish which gave strength to them brought death to the chief because of his cruelty to Kū'ula, his faithful fisherman.

After that day 'Ai'ai went about Hawai'i-nei. He showed men good fishing grounds and taught them many ways of catching fish. He established shrines. Sometimes a shrine was a heap of stones, sometimes an image carved like a person. One such was Mālei, a figure of white stone which stood long above Makapu'u on O'ahu. Fishermen hung lei of seaweed about Mālei. They prayed to her and came home with full canoes. They laid their first-caught fish before her and offered thanks. The fishermen of that district love Mālei and longed to see her as a living goddess. Some saw her in their dreams. They heard her chants and learned and chanted them.

Many such shrines were brought or built by 'Ai'ai. Men called each a kū'ula in memory of the great fisherman of Maui whom they now worshiped as their god. Those shrines became landmarks for travelers among the islands of Hawai'i-nei.



Game Instructions

Game Set-up

Place each gameboard on a flat surface in a cleared area of the classroom. Distribute game pieces: one per ʻohana group. Shuffle the kiaʻi cards and stack them face down on the square marked kiaʻi. Do the same for the kuleana cards, stacking them on the kuleana square. Each loko iʻa card should be placed face up just off the gameboard next to the respective loko iʻa square.

Objective

The objective of the game is to collect all 6 loko iʻa cards and to discover important values and practices related to fishing and fishponds in early Hawaiʻi.

To Win the Game

The ʻohana with the most loko iʻa cards at the end of 30 minutes wins the game!

Directions

1. Have each ʻohana place a game piece on one of the loko iʻa squares. (Only one game piece per loko iʻa.)

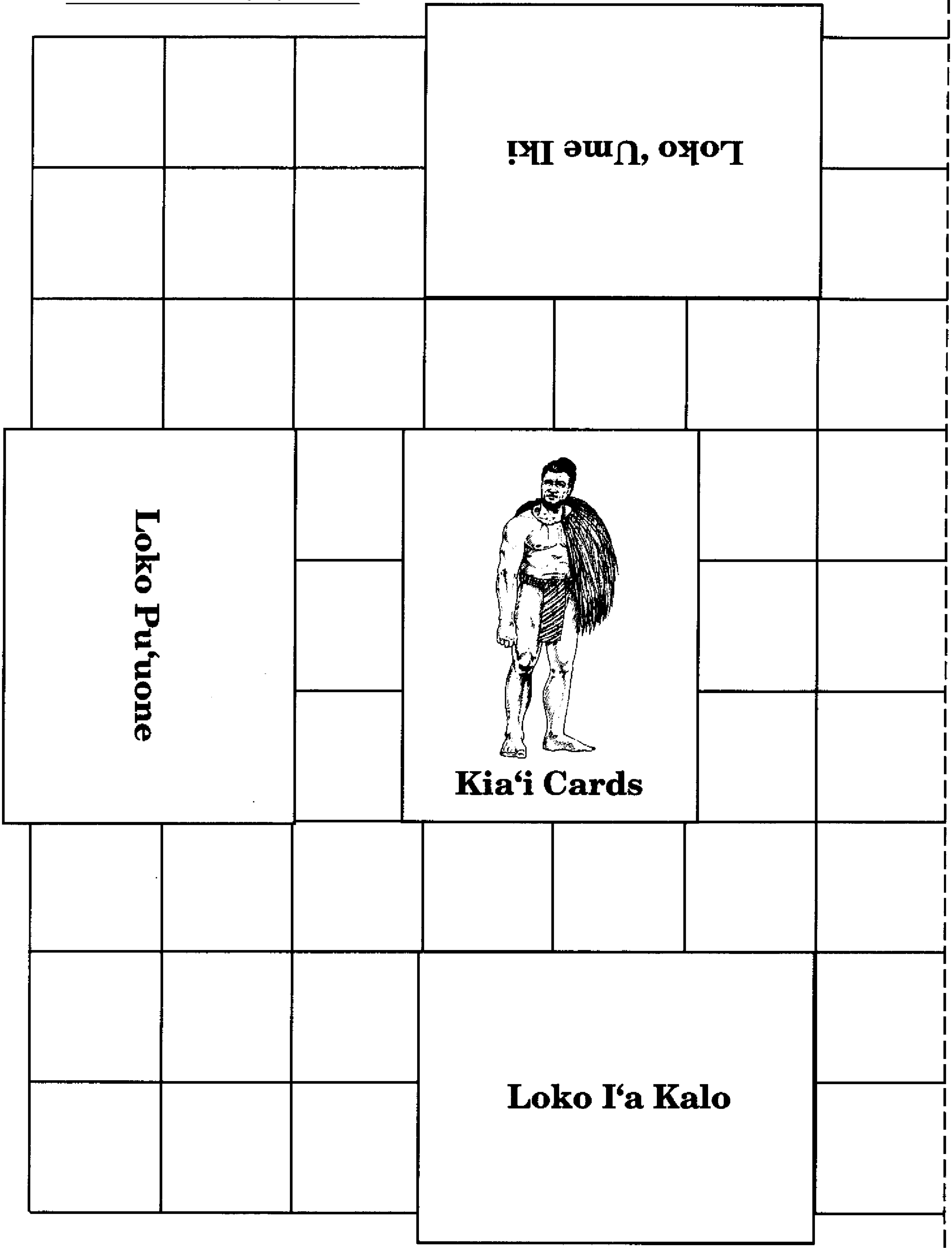
2. Roll the dice to determine who begins the game. The ʻohana with the highest number wins the first turn, followed by the ʻohana to the right and continuing counter-clockwise.

3. The ʻohana who begins the game rolls the dice and moves the game piece the number of squares indicated by the roll of the dice. Each ʻohana:
   - must only move the number of squares rolled
   - may move horizontally or vertically, forward or backward – but not diagonally
   - may change directions during a move but may not enter the same square twice during the same turn
   - may not enter or land on a square that's already occupied by another ʻohana, although two or more ʻohana may land on the same loko iʻa.

4. As the ʻohana lands on a loko iʻa square, the group to their right draws a kiaʻi card and reads the card aloud. The ʻohana has 30 seconds to answer the question.

5. If the ʻohana correctly answers the question within the 30-second time limit, they acquire that loko iʻa card. If they are unable to answer the question, the ʻohana group does not collect that loko iʻa card and must try again.

6. If an ʻohana draws a card from the kiaʻi stack marked "kuleana," they must draw a card from the kuleana stack and follow the directions described on the card.



Trim page on dotted line and tape two halves of game board together.

Trim page on dotted line and tape two halves of game board together.

Loko Kuapā

Kuleana Cards

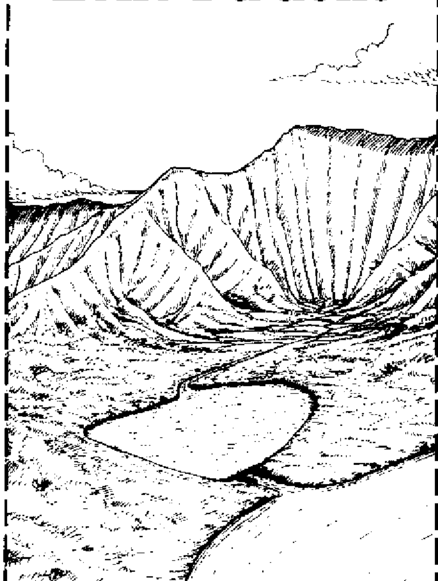
Umu

Loko Wai

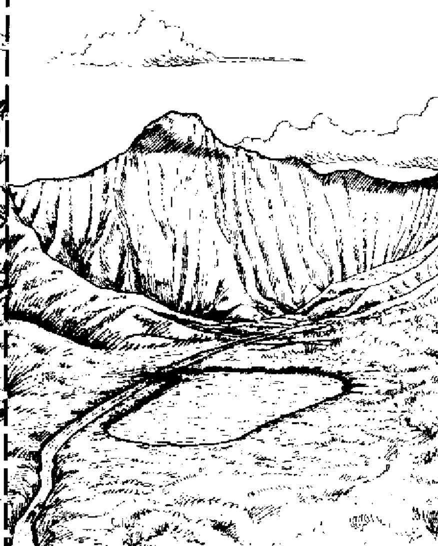
Loko I'a Cards

Make 6 copies. Cut and laminate.

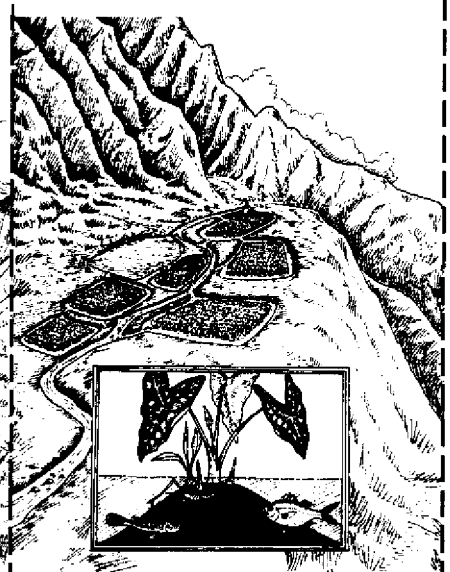
Loko Pu'uone



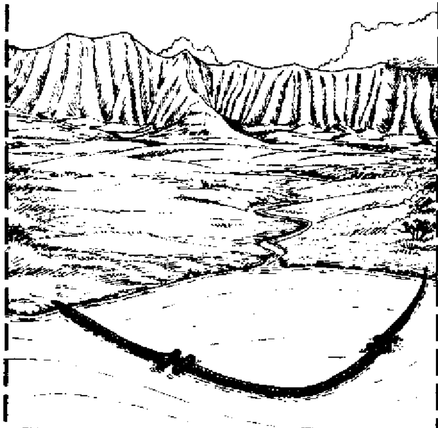
Loko Wai



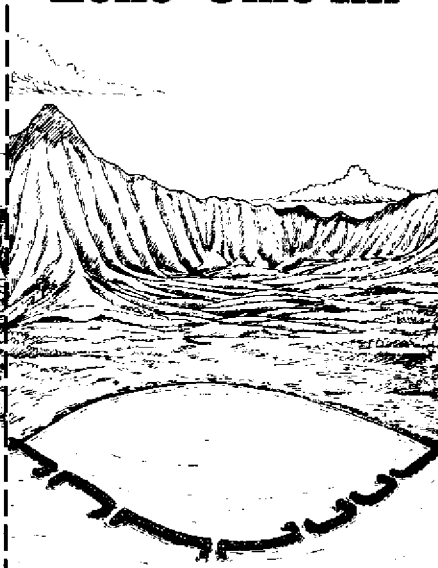
Loko I'a Kalo



Loko Kuapā



Loko 'Ume Iki



Umu

Kia‘i Cards (front)

Make 2 copies. Cut and laminate.

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kiaʻi Cards (back)

Make 2 copies. Cut and laminate.

The kiaʻi notices the ʻamaʻama nibbling something at the surface of the pond. What are the tiny plant and animal organisms in plankton called?

Phytoplankton and zooplankton

The kiaʻi had to place additional fertilizers into the pond. Name at least three kinds of "natural fertilizers" he might have had to add.

Uala (sweet potato)
ʻUlu (breadfruit)
Kalo (taro)
Mussels
Stones with seaweed

The kiaʻi saw large amounts of limu growing near the north side of the fishpond. He has asked your ʻohana to help remove it. Why would it be necessary for you to remove the excess limu from the loko iʻa?

Too much limu depletes dissolved oxygen, which is important to the pond's ecosystem.

Auē! Several stones have fallen loose, leaving a small gap in the pond wall near the mākāhā. The kiaʻi has asked for your help in rebuilding. Why are the fishpond walls and mākāhā critical to maintaining a healthy ecosystem?

To control water circulation and prevent build-up of sediments

The kiaʻi smells a foul odor coming from the fishpond. You notice the water is very still. What is this called?

Stagnant water

Your ʻohana decides to build their hale (home) away from the stream. What is one reason why they locate their homes away from fishponds?

- *To avoid pollution caused by human waste*
- *To protect the water quality*
- *By order of the konohiki to discourage poaching*

Auē! Your kiaʻi notices several of the ʻamaʻama and awa (herbivore fish) floating in the loko iʻa. Identify one reason why this could have happened?

Too much limu, not enough oxygen, pollution

The limu and plankton are not growing in the loko iʻa. The kiaʻi makes a hypothesis. The water has become too cloudy. Why would this cause the problem?

Plants need sunlight for the process of photosynthesis.

There are several crabs in the fishpond. How do they contribute to the health of the pond?

They help to break down dead plants and animals and recycle the nutrients back into the pond.

Kiaʻi Cards (front)

Make 2 copies. Cut and laminate.

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Card

Kiaʻi Cards (back)

Make 2 copies. Cut and laminate.

Auē! The kiaʻi notices the fishpond becoming choked with silt. Why is this a problem?

Too much silt can cause the water to be cloudy and decrease sunlight that plants need; it also can lead to loss of oxygen when organic matter in the silt decays.

The kiaʻi told your ʻohana that the moʻo wahine appeared the other day. Why are these spirit guardians associated with fishponds?

They protect the fishponds.

A fisher is seen making an offering near the Kū stone at the fishpond. Who are the two gods connected to fishponds and why were they so significant?

Kūʻula and Hina. The offering was made to the gods to ensure a plentiful catch.

Auē! One of the slats in the mākāhā has eroded. The kiaʻi has you gather wood to repair it. What is one function of the mākāhā?

- *To allow pua iʻa into the pond*
- *To prevent larger fish from escaping*
- *To allow the flushing of sediment and water circulation*

In the story *Kū'ula: God of Fishermen*, when did Kū'ula exhibit the value of generosity?

When he shared his fish catch with his neighbors.

In which situation did Kū'ula show the value of faithfulness to his aliʻi?

Although the chief blamed Kūʻula, he did not question the chief's order.

Who was ʻAi'ai and what is one value that describes ʻAiʻai best?

Devoted. He obeyed his father's orders even though he knew they were at risk of dying.

Courageous. He fought the eel.

Why did the people of Molokaʻi worship the eel?

It destroyed a man-eating shark.

Name one quality (good or bad) that describes the aliʻi. Why?

Trust. Good – he trusts those under him. Bad – he believes the words of an unfaithful servant.

Kia‘i Cards (front)

Make 2 copies. Cut and laminate.

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kiaʻi Cards (back)

Make 2 copies. Cut and laminate.

What happened to Kūʻula and Hina after their hale was set on fire? *They became fish and served as fishing gods.*	How would you describe ʻAiʻai's relationship with Kūʻula? *ʻAiʻai was devoted to his father and respected him.*	Why would you call Kūʻula a wise and trusted leader? *He was devoted to the people and not to the cruel chief.*
How did some people of Hāna react when they heard that Kūʻula, Hina and ʻAiʻai would be put to death? *They were upset and did not participate in the preparations; they remained devoted to the fishing family.*	Kūʻula gave ʻAiʻai a hook made of pearl and a cowry for catching octopus. How was ʻAiʻai expected to use these tools? *Kūʻula wanted ʻAiʻai to use the tools as a way to teach the people of Hawaiʻi how to fish.*	What did ʻAiʻai do to help the people of Hāna? *He taught them how to fish.*
What is the name of the stone altars built at fishponds? *koʻa - fishing shrines*	What is the ritual that Hawaiians go through before they fish? *They pray and make offerings. When they return from fishing, they offer the first fish they caught at the fishing shrine.*	Why did the chief die when he ate the hīnālea (wrasse)? *It was punishment from the gods because the chief had been so cruel to his faithful servant, Kūʻula.*

Kia‘i Cards (front)

Make **4** copies. Cut and laminate.

Note: 12 "Pick a Kuleana Card" needed per gameboard.

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kia‘i Card

Kiaʻi Cards (back)

Make 4 copies. Cut and laminate.

Note: 12 "Pick a Kuleana Card" needed per gameboard.

Pick a kuleana card	**Pick a kuleana card**	**Pick a kuleana card**
Pick a kuleana card	**Pick a kuleana card**	**Pick a kuleana card**

Kuleana Cards

Make 2 copies. Cut and laminate.

Kuleana Card

Kuleana Card

Kuleana Card

Kuleana Card

Kuleana Card

Kuleana Card

Kuleana Cards

Make 2 copies. Cut and laminate.

The konohiki has ordered everyone to clean the ʻauwai (irrigation ditches) of the loko iʻa kalo. You lose a day's work in the loʻi. *Skip your next turn.*	Your ʻohana decides to build a loko wai, which still allows plenty of fresh water and nutrients to flow downstream. *You may advance to the loko wai and collect the card.*	Part of the sand that holds water in the loko puʻuone eroded away in a tsunami. Your ʻohana must hurry to help the others rebuild. *You may advance to the loko puʻuone and collect the card.*
Auē! Your aliʻi's enemies have destroyed the loko kuapā in the ahupuaʻa in which you live. Everyone's attention must be devoted to the rebuilding of the loko kuapā. *Skip your next turn.*	Everyone is preparing for a huge feast to celebrate the Makahiki season. Your ʻohana must help the kiaʻi catch fish from the loko kuapā. *You may advance to the loko kuapā and collect the card.*	Tūtū's umu has fallen apart. You help her to rebuild it. *You may advance to the umu and collect the card.*

Kuleana Cards

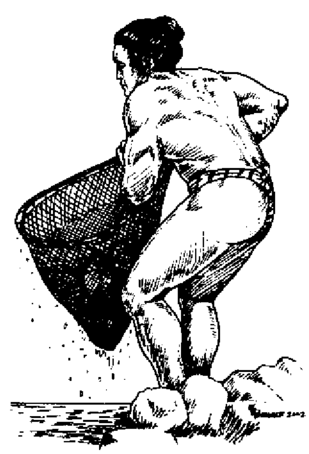
Make 2 copies. Cut and laminate.

Kuleana Card

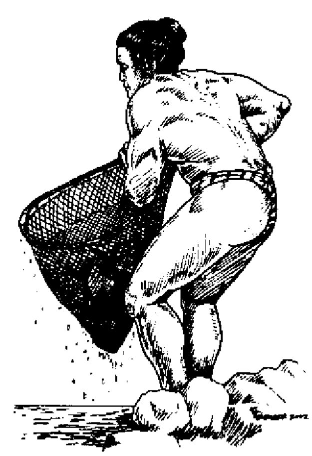
Kuleana Card

Kuleana Card

Kuleana Card



Kuleana Card



Kuleana Card

Kuleana Cards

Make 2 copies. Cut and laminate.

A stranger has come to your hale and is hungry. Your ʻohana welcomes him and prepares food. You go to your loko iʻa kalo to catch several ʻoʻopu. *You may advance to the loko iʻa kalo and collect the card.*	The lanes of the loko ʻume iki are teeming with ʻamaʻama. Your ʻohana runs to the shoreline to catch some. *You may advance to the loko ʻume iki and collect the card.*	Auē! Pele is furious and has spewed lava, which has destroyed some of the fishponds within your ahupuaʻa. Your ʻohana can only eat vegetables until the fishponds have been rebuilt. *Move back 3 spaces. You may not land on a loko iʻa.*
The konohiki has ordered your ʻohana to pay more taxes. You must collect all the fish from your loko iʻa kalo to make your aliʻi happy. *Give the ʻohana to your right a loko iʻa card from your pile.*	Auē! Heavy wind and rain has damaged the shoreline ponds. You must fish for food in the open ocean and you are gone from your family for days. *Give the ʻohana to your left a loko iʻa card from your pile.*	A dog stole a fish from the aliʻi's fishpond. However, your ʻohana was blamed for it. *Move back 5 spaces. You may not land on a loko iʻa.*

Fishpond Fall

- What has caused the decline of Hawaiian fishponds over time?

Hawaiʻi DOE Content Standard

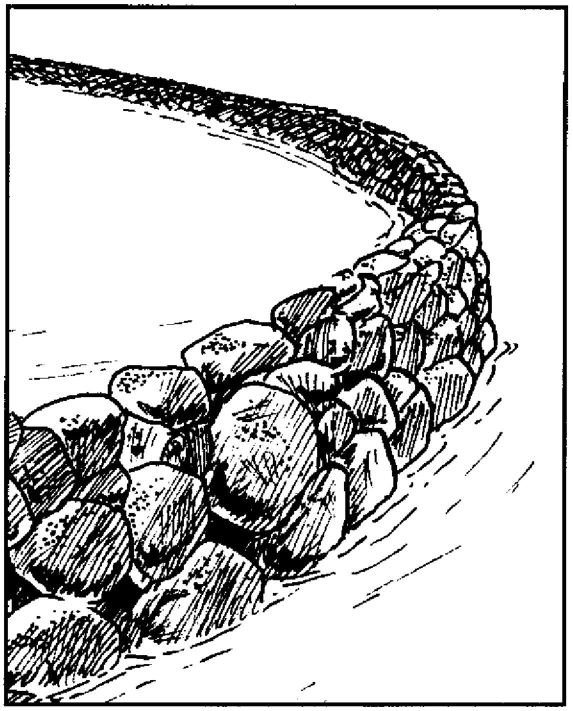
Social Studies: Change, Continuity and Causality:
- Students employ chronology to understand change and/or continuity and cause and/or effect in history.

Grade 6 – 8 Performance Indicators

- Select key people, events and/or ideas in an era(s).
- Organize the key people, events and/or ideas into a chronology.
- Using the chronology, explain how key people, events and/or ideas changed or stayed the same over time.

Key Concept

Many factors contributed to the decline of Hawaiian fishponds, including battles, the introduction of diseases, the sandalwood trade, the Great Mahele, natural disasters, land development, and changes from a subsistence to a market economy.



Activity at a Glance

Students create a historical timeline that reflects the many events that led to the decline of fishponds.

Time

3 - 4 class periods

Skills

reasoning, analysis, writing

Assessment

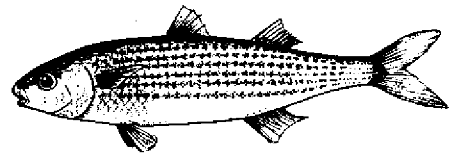
Students:
- Complete a timeline that shows the chronology of events that contributed to the decline of fishponds.
- Create a drawing or write a summary of how key people, events and/or ideas affected fishponds over time.

Vocabulary

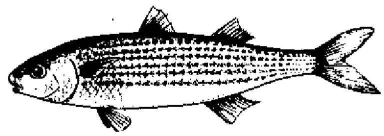
aquaculture – the cultivation of aquatic animals and plants in a natural or controlled saltwater, brackishwater or freshwater environment
decimate – to reduce drastically, especially in number
Raiatea - the second largest Island in the French Polynesian Archipelago known as the Society Islands, located directly between Bora Bora and Tahiti
sandalwood – the fragrant wood of certain trees used for ornamental carving and burned as incense

Materials

Provided:
- timeline date labels
- historical account cards
- event cards
- student activity sheet

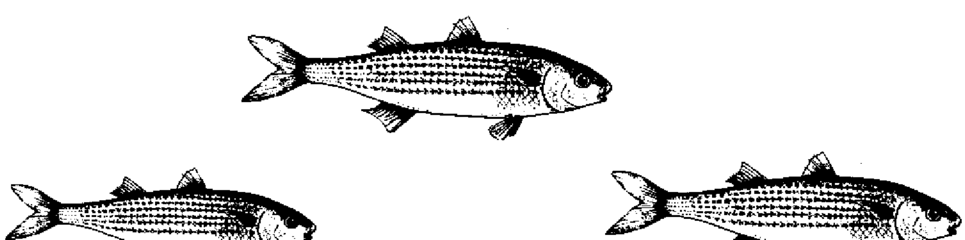


Needed:
- 1 ball of twine
- masking tape
- small container
- labels for six stations in the classroom



Advance Preparation

- Set up six stations around the room with the following labels:
  - Period 1: A.D. 100 – 1600
  - Period 2: 1700 – 1790
  - Period 3: 1800 – 1819
  - Period 4: 1830 – 1853
  - Period 5: 1900 – 1946
  - Period 6: 1947 – present
- Copy the historical account cards, cut them out and laminate, if desired. Place the appropriate cards at the six stations.
- Stretch about 15 feet of twine across the front wall of the classroom (above the board). Copy the timeline date labels and tape them to the twine.
- Make a copy of the student activity sheet for each student.
- Copy the event cards, cut them out, and place them into a small container.



Teaching Suggestions

1. Write the following statements on the board:

   In the early 1900s less than 100 of the original 488 Hawaiian fishponds and fishtraps were still in operation. Today only a few ponds are in operation or being restored.

2. Ask students to share ideas about what events they believe may have led to the decline of fishponds and fishtraps over time. Tell students that they will be going on a historical journey that will address the question.

3. Ask pairs of students to draw one event card from the small container. Two students will share one card. Show them the six stations set up around the room and challenge them to go to the station that they think matches the time period when their event occurred.

4. At the stations, students should read the historical account cards to see if their events are listed for that time period and to find information to answer questions on their cards. If they are in the wrong period, students should move to another station.

5. When students have grouped themselves correctly into the six stations, ask them to discuss all of the events on the historical account cards for that period. Challenge each group to determine which events are most significant for the loss of fishponds (or in the case of station 1, events significant for the construction of ponds). Ask them to develop a way to teach that information to their classmates through oral presentation, role-playing, or storytelling.

6. Distribute the student activity sheet and encourage students to complete it as their classmates present the significant events in their time periods. As students present, have them tape each event card to the twine in the appropriate time period to create an historical timeline.

7. In the assessment activity, ask students to complete the sequence of events on the activity sheet and summarize the key events that led to the decline of fishponds and fishtraps. See the culminating activity described in Unit at a Glance for building on what students have learned.

8. Discuss students' ideas about the factors that led to the decline of fishponds and fishtraps.

   Discussion Questions

   - What were some of the factors that led to the decline of fishponds and fishtraps? Which of these factors do you think had the most impact?
   - Is there anything that could have been done to prevent the rapid decline? What is it? (Be specific.)
   - What purposes could the fishponds serve today if they were restored?
   - What can we do today to help preserve and protect the remaining fishponds and fishtraps?

Adaptations/Extensions

- Read the story of "Kanekua'ana" (provided at the end of this unit) to the class. As you read, ask students to guess where the story takes place. *(Answer: Pu'uloa, now known as Pearl Harbor.)* Explain to students that at one time Pu'uloa had more than 36 fishponds and fishtraps, comprising one of the most extensive systems of aquaculture in the Islands. Early Hawaiians raised many different kinds of fish in the area and oysters were abundant. Early Hawaiians cultivated oysters – not for the pearls – but for the meat. Today, almost all the fishponds and fishtraps of Pu'uloa have been destroyed.

- Divide the class into two teams. Have each student compose a question (and an answer) based on the information they acquired in this activity. Use their questions in a "Fishpond Feud" game. Place their questions in a container. Pull one question from the container and read it aloud. The first team to raise hands may answer the question. If students are correct, the team is awarded one point. No points are awarded for an incorrect answer. Continue until all the questions have been answered. The team with the most points wins.

- Encourage students to interview a kupuna who may have information about a fishpond or who may be involved with the restoration of a fishpond and ask him/her to share stories and experiences. Students should document these stories and invite the kupuna to share with the other students in the class.

- Have students illustrate each time period or create a class mural of the timeline they have created.

- Have students create a play that presents the events they have learned about in this activity. They could select music, design sets and costumes, and perform for the younger grade levels.

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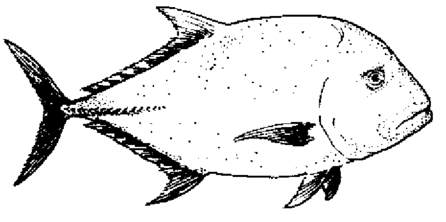
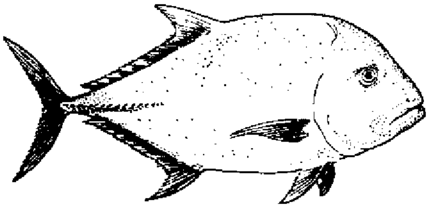




Timeline Date Labels

Make 1 copy. Cut and laminate.

A.D. 100 - 1600

1700 - 1790

1800 - 1819

1830 - 1853

1900 - 1946

1947 - Present

Event Cards

Make 1 copy. Cut and laminate.

Migration

When did the first Polynesians arrive in Hawai'i?
When did the second phase of Polynesian migration to Hawai'i take place?

First Fishponds

When were the first fishponds built and who constructed them?

Hawaiian Battles

When did wars occur in the Islands?
How did these battles affect fishponds?

Introduced Diseases

When did introduced diseases begin affecting the Native Hawaiian population?
What is the connection between diseases and the decline of fishponds?

Sandalwood Trade

What was the sandalwood trade and when did it occur?
How might it have contributed to the loss of fishponds?

Introduced Animals

When were large animals like cattle, sheep, and horses introduced to the Islands?
What impact could they have had on fishponds?

Event Cards

Make 1 copy. Cut and laminate.

Kapu System Ended

How and when was the Hawaiian kapu system ended?
What impact did the loss of this system have on fishponds?

Whaling Industry

When did the whaling industry emerge in Hawai'i?
How did this early shift toward a cash economy affect fishponds?

Sugar Cane Plantations

When did sugar cane plantations begin operation?
Was there a connection between sugar production and fishponds?

Great Mahele

What was the Great Mahele and when did it occur?
What effect might this have had on fishponds?

World War II

When did World War II occur?
What effect did the war have on fishponds in the Islands?

Tsunami

When did the last major tsunami hit the Islands?
What was the impact on fishponds?

Event Cards

Make 1 copy. Cut and laminate.

Introduced Plants

When and why were mangrove trees brought into the Islands?
What impact have these trees had on fishponds?

Housing Development

When did large-scale housing development begin in the Islands?
In what ways did the creation of new neighborhooods affect fishponds?

Act 216 of Territory of Hawaiʻi

What is Act 216? How was this Act designed to affect fishponds?

Student Activity Sheet Name________________

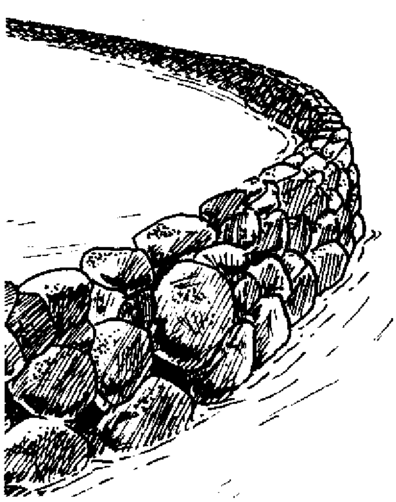
Summarize the significant events that led to the construction of Hawaiian fishponds and their decline over time.

Period 1: A.D. 100 – 1600

Period 2: 1700 – 1790

Period 3: 1800 – 1819

Period 4: 1830 – 1853



Period 5: 1900 – 1946

Period 6: 1947 – Present

Historical Account Cards

A.D. 100 - 400 — Period 1

The exact reason the Marquesans begin their voyage that leads them to Hawai'i will never be known. Some believe fishers from the Marquesas Islands are sent far out to sea to search for ideal fishing grounds. Others believe that war, severe climate and lack of natural resources force the Marquesans to leave their islands to search for new lands. About A.D. 447, the first group of Marquesans is believed to have arrived in the Hawaiian Islands and settle at Bellows Beach in Waimānalo, O'ahu. They discover that the islands of Hawai'i have valleys with many streams, and along the shoreline are small inlets and coral reefs important for fish cultivation.

"The Marquesans initially created three principal communities on O'ahu at Waimanalo, Kaneohe and Kailua. These offered conditions which clearly were most agreeable for their fledgling community; year-around fresh running waters, timbered and fertile valleys, offshore reefs which attracted marine life, sheltered lagoons for fishpond aquaculture and the highest grade of basaltic rock (used for stone tools)" (Hall III, 1997).

1000 — Period 1

Raiateans arrive from French Polynesia between the 9th and 15th centuries. They are fierce warriors enslaving the Marquesans whom they refer to as the "small people" or manahune (in Hawaiian culture, menehune). Thousands of these menehune are ordered to build fishponds. The Raiateans set up the social structure that would later govern the ahupua'a.

"The second phase of Polynesian migration to Hawai'i took place about A.D. 1000. Authorities are of the opinion that when the newcomers arrived in the Hawaiian Islands they promptly set about conquering the Marquesans already settled there...and [the Marquesans] became the working class under the new rulers" (Donohugh, 2001).

"Of the fishponds, Alakoko (or Alekoko) on Kaua'i and Huila on O'ahu were said to be built by Menehune....Their stonework includes heiau temples, 'auwai watercourses and fishponds" (Wyban, 1992).

Historical Account Cards

1300 — Period 1

More than 30 fishponds in Kāne'ohe Bay are already constructed. Tahitians develop an extensive agricultural system of lo'i kalo (taro patches) and loko i'a (fishponds) at Ka'elepulu pond and Kawainui marsh in the Kailua, O'ahu, area.

"...it is along and in the streams which rush through the bottoms of these narrow gorges that the Hawaiian is most at home. Go into any of the valleys, and you will see a surprising sight: along the whole narrow bottom and climbing often in terraces...you will see little taro patches, skillfully laid so as to catch the water, either directly from the main stream, or from canals taking the water out above....Down near the shore are fishponds, with wicker gates, which admit the small fry from the sea, but keep in the large fish" (Dieudonne, 2002).

"Po'alima was a work day, literally the fifth day of the week, when people in the community would work on the chief's taro lo'i and fishponds. Po'alima assured that maintenance of fishponds was continued" (Farber, 1997).

1450 — Period 1

Fishponds are rebuilt at Keone'ōi'o (on Maui) after a lava flow damaged the original pond. Waikīkī becomes the central site for the ali'i.

1500 — Period 1

The high chiefess Kala-manuia orders the construction of Kapa'kea, 'Opu, Pa'aiau and Loko Pa'kea, fishponds in Pearl Harbor. On Moloka'i, Chief Lohelohe is said to be responsible for the construction of Keawanui fishpond and Mikiawa fishtrap.

1600 — Period 1

An invading army of Chief Kama-lala-walu of Maui sends spies to Kīholo Bay on Hawai'i Island. The spies observe that the fishponds of Wainānāli'i are in full operation.

Historical Account Cards

1700 **Period 2**

Battles are occurring throughout the Islands. Fishponds, which are symbols of power and wealth, are ordered to be destroyed by rival chiefs in order that they may conquer more lands.

"Each fishpond was always associated with one and only one land unit...The wealth and power of a chief was measured in his lands and the production of those lands....Under conditions of war, a great deal of destruction was done in order to cripple the opponent" (Kikuchi, 1973).

"Having gained Hilo, Keōua...descended into Waipi'o and broke down the fishponds, drying up Lalakea, Muliwai, and all the other ponds. He pulled up the taro of Waipi'o, broke down the banks of the taro patches, and robbed the people...Such were the bitter fruits of war" (Kamakau, 1992).

1736 **Period 2**

An O'ahu chief, Kapi'ioho'okalani, wages war on the people of Moloka'i causing the people to flee to the mountains to escape his destruction. Kapi'ioho'okalani orders his men to tear down walls and destroy the fishponds. The battle continues for five days until Kapi'ioho'okalani and some of his warriors are slaughtered. Those who remain alive, return to O'ahu.

"The presence of a large fishpond indicated to any possible enemy that this chief and his people were united, at his command, and he could field an army to defend his territory from attack" (Farber, 1997).

1778 **Period 2**

Captain James Cook arrives in the Islands. The Hawaiian population at the time is approximately 300,000; 60,000 live on the island of O'ahu. Diseases are introduced: venereal, smallpox, measles, colds, and leprosy. Between 1778 and 1823, or 45 years from the time Cook arrives in the Islands, the native population declines by 80 percent. Many commoners who maintain the fishponds are lost to disease.

Historical Account Cards

1778 **Period 2**

When Captain James Cook arrives in the Islands, Hawaiians do not understand the concept of trading food and materials for profit. Their economy is based on sharing resources. But they learn quickly, trading food for iron materials and weapons.

"The introduction of new goods and materials, plants, animals, diseases for which the Hawaiians had no immunity, and foreign beliefs, customs and institutions ultimately led to the destruction of the Hawaiian religion and the chiefs' right to control the land, its resources and its people" (Farber, 1997).

1790 **Period 2**

Kawainui in Kailua, O'ahu, becomes the breadbasket for King Kamehameha's armies. Kamehameha spends time hunting in this area and fishing in Kawainui and Ka'elepulu ponds. To set an example for his people, Kamehameha works alongside his people cleaning the fishponds.

1800 **Period 3**

An estimated 360 fishponds are in production throughout the Islands. A lava flow in North Kona destroys several fishponds. The people believe that Pele wants to consume the awa (milkfish) from two of the ponds. The flow destroys houses, topples coconut trees and fills fishponds with lava. Kamehameha I appeals to Pele, offering sacrifices and gifts, which halts the flow, but not before the lava destroys the ponds.

1800 **Period 3**

Cattle, sheep, and horses are introduced to the Islands. Kamehameha I places a kapu on destroying the animals. Animals are allowed to roam freely and reproduce. As a result, soil erodes downstream into fishponds, depleting pond life and causing siltation.

"Presented as a gift to Kamehameha, the king would place a Kapu on the 'pipi' (beef cattle) and, grazing freely, their numbers would grow quickly. In 1803, the first horses are shipped to Hawaii. Also protected by a kapu, the 'lio' (wild mustangs) could be found roaming at will" (Hall III, 1997).

Historical Account Cards

1805 - 1810 Period 3

The sandalwood trade enters its boom years. More and more foreigners begin visiting the Islands, bringing with them new technology and materials. Iron, masts and guns make an enormous impression on the ali'i. Possessing these materials symbolizes power and wealth. Ali'i discover that sandalwood is highly prized by foreigners so they require their people to spend less time tending the fishponds and lo'i kalo and more time cutting down sandalwood trees. The ali'i profit from the sandalwood trade while their people experience food shortages and starvation.

"[Several captains of boats] informed the king [Kamehameha I] and his chiefs that the fragrant sandalwood was a valuable article of trade with the people of China. The king, accordingly, when he returned to Hawai'i, sent his people to the mountains after this wood" (Kamakau, 1992).

1819 Period 3

King Kamehameha I dies. The kapu system is ended and the many konohiki no longer have the right to command people to work. The maintenance and repair of fishponds decline. Diseases continue to deplete the Hawaiian population. Those who have the expertise to build fishponds gradually disappear.

"In the wake of Kamehameha's death these two feminists [Ka'ahumanu and Ke'ōpuolani] *would conspire to liberate all Hawaiian women from the oppressive kapu system in one fell sweep by taking their seats at the table of...Liholiho"* (Hall III, 1997).

1830 Period 4

The whaling industry emerges and many young Hawaiians move to Honolulu and Lahaina hoping to earn good wages. Those who continue to practice agriculture begin growing food for sale. Fish are raised and sold. Instead of sharing resources in a subsistence economy, people start raising and selling fish and other goods, beginning the shift to a market economy.

"It was the first time that masses of Hawaiians were drawn into the cash economy as regular paid wage earners. Many young Hawaiians attracted to the promise of town life left the land for Lahaina and Honolulu. Hawaiian agricultural workers began growing food expressly for sale, further undermining the subsistence economy" (Farber, 1997).

Historical Account Cards

1835 - 1847 **Period 4**

The first large-scale sugar mill begins operation when a 50-year lease on land is signed at Kōloa, Kaua'i. Workers are drawn to the plantation to receive wages and benefits. Perhaps the change in land use and especially the building of dams and irrigation systems for the growing of sugar cane contributed to the flooding that occurred in 1847.

"Signed by Kamehameha III and Governor Kaikio'ewa of Kaua'i, this lease was the first of its kind in the history of Hawai'i. It was also the first formal recognition of the right of someone other than a chief to control land. This profoundly affected traditional notions of land tenure dominated by the chiefly hierarchy throughout the islands. In 1847...a flash flood...swept away most of the Hawaiian houses in Kōloa, ruined taro patches and fishponds, and even damaged the sugar mill" (Donohue, 2001).

1848 **Period 4**

The Great Mahele is proclaimed by Kamehameha III. During this period of land division, lands that were originally managed by the ali'i and maintained by the people are converted to private land ownership. Most of the fishponds are awarded to the ali'i. However, ali'i no longer have control over their people to maintain the fishponds. The Hawaiian population throughout the Islands drops to 82,000 after a measles epidemic. Fishponds fall into disrepair or are leased out to foreigners.

"The Mahele and Kuleana Act resulted in about 70 percent of the adult male population, along with their wives and children, rendered landless at a moment when it was crucial to obtain a plot of land to live on and cultivate to support one's family" (Farber, 1997).

"The ponds that were not maintained either fell into disrepair or were leased to and operated by Chinese (77) followed by Hawaiians (23) and Caucasians (less than 1)" (Farber, 1997).

1850 **Period 4**

The Resident-Alien Act becomes law, allowing foreigners to buy land. Most of the lands that were made available for the ali'i and the commoners under the Great Mahele are lost to foreigners. By 1851, the traditional system of owning and operating fishponds is gone.

Historical Account Cards

1851 — Period 4

Fifty-five Hawaiian farmers from windward O'ahu send a letter to the King's government stating that 'We are in trouble because we have no firewood and timber for houses...our children are eating raw potato for lack of firewood and their mouths swell from eating raw taro.' Without money for sustenance, the farmers are forced to relinquish title to their land.

"As fishponds and sea fisheries were declared private property under the new laws, the common people soon became trespassers in their own lands" (Kelly, 1975).

1853 — Period 4

More diseases are introduced to the Islands from the Orient and the West. Native Hawaiians have no immunity to these diseases and a small pox epidemic kills more than 7,000 on O'ahu. The population in the Hawaiian Islands dwindles to 75,000. The people are in despair.

1900s — Period 5

Mangrove trees are introduced to the Islands to prevent soil erosion. The American Sugar Company plants seedlings on the upper slopes of Moloka'i. However, the mangroves quickly spread to the coastline where they thrive in brackish water. The mangroves begin to extend to the shallow areas of fishponds and the root systems become established within the walls. This causes sediment to be trapped, turning some fishponds into wetlands and mudflats. Mangroves block sunlight, preventing the growth of limu, on which the 'ama'ama (striped mullet) feed.

"...the first trees planted on the Moloka'i Ranch were set out before I came to the ranch in 1908. The trees are from seed that came from Florida. The planting...was for the purpose of holding back soil that is being washed down by very heavy rain into the sea, and also as a pasture plant for bees" (MacGaughey, 1917).

Historical Account Cards

1902 **Period 5**

There are 99 fishponds in production statewide.

"Ninety-nine fishponds were in production in 1900, Kaua'i - 6, O'ahu - 74, Moloka'i - 15, and Hawai'i - 4. These ponds combined employed a total of 191 people" (Cobb, 1902).

"In 1902, there were 99 ponds producing 682,464 lb. of fish; today (1994) we have six ponds State-wide yielding 31,639 lb. of fish...." (Farber 1997).

1903 **Period 5**

More families from rural areas move to urban areas. Fishponds that were tended by families are no longer being cared for and fewer people are selling fish. Families have difficulty transporting fish to sell since the availability of ice is limited. Importing fish and local ocean fishing costs less and the labor is not as complex as maintaining a fishpond. Commercial fishpond operators are unable to compete with the more productive way of obtaining fish, and many fishponds are abandoned.

"The native population is rapidly disappearing, and where there were prosperous and populous villages in the early years of the last century there is practically a wilderness now. Owing to this depopulation there is no sale of fish in the immediate neighborhoods of the ponds there. The ponds have naturally been allowed to decay, the walls breaking down from the action of the storms, and the sea filling them with sand if they are located on the immediate shore. This condition is especially prevalent on Moloka'i" (Cobb, 1903).

1918 **Period 5**

Artillery batteries are constructed around O'ahu's south shore. Ten loko wai in Kalia (Fort DeRussey) are dredged and filled in.

"The area once known as Kalia (now Fort DeRussey) was the site of 10 loko wai. These large fishponds were also home to ducks and other waterfowl. Taro and sweet potatoes were grown, fed through an elaborately designed system of 'auwai (water channels)" (Dieudonne, 2002).

Historical Account Cards

1941 **Period 5**

America enters World War II when the Japanese attack Pu'uloa (Pearl Harbor). The American military occupation of Pearl Harbor has destroyed many of the fishponds and fishtraps. Several accounts indicate that at one time there were close to 36 fishponds and fishtraps in the area. *"On Pearl Harbor, O'ahu, two fishtraps are used for catching sharks and large akule (goggler), opelu (mackeral scad), weke (goat fish), and kawakawa (bonito)"* (Sterling, 1993). *"The development of Pearl Harbor by the military destroyed some of the oldest and most unique fishponds and fishtraps in Hawai'i"* (Farber, 1997).

1946 **Period 5**

A major tsunami hits the Islands. It is the most destructive natural disaster in Island history, causing $25,000,000 in property damage. Many fishponds are destroyed.

"Of a total of 85 tsunami recorded since 1813, 6 were severe enough to have caused extensive damage to both life and property, while 15 were of significant force to have caused lesser damage. The tsunami of 1946 did considerable damage to Ku'uali'i and Kahapapa fishponds on Hawai'i, Kupeke fishpond and Honouliwai fishtrap on Moloka'i, and Alekoko and Lawa'i Kai fishponds on Kaua'i" (Kikuchi, 1973).

1947 **Period 6**

Due to an increase in population and tourism, there is more demand for housing and resort development. Kalokohanahou, a 14-acre fishpond in Kāne'ohe Bay on O'ahu, is filled in to pave the way for residential development. Fishpond owners sell their lands at premium prices.

"...many of the fishponds of Kāne'ohe Bay were filled shortly after World War II. Most others continue to deteriorate from neglect" (Devaney, 1982).

"The extensive loko wai in Waikīkī and many of the ponds in the Kāne'ohe area were filled in and developed for housing and hotels. Urbanization, particularly on O'ahu, has altered or destroyed many of the fishponds. Population pressure, changing shoreline use and resort development resulted in the filling in of fishponds. As recently as 1971, Puko'o fishpond on Moloka'i was destroyed for resort development" (Farber, 1997).

Historical Account Cards

1955 **Period 6**

As a result of efforts to restore the fishponds as a means of solving food problems during wartime, Act 216 of the Session Laws of the Territory of Hawai'i is finally enacted. This legislation calls for the rehabilitation and reconstruction of fishponds that are located on government lands and the lease of public fishponds to private persons.

"With minor modifications to the language but with its overall intent intact, this legislation has been in effect up to the present day (in 1985 to the present known as Act 171-28)" (Farber, 1997).

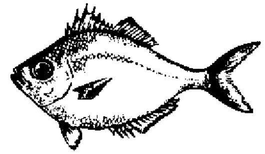
1994 **Period 6**

Only six fishponds are producing fish statewide – Mōli'i, He'eia, Lokoea on O'ahu, 'Ualapu'e on Moloka'i, and LokoWaka and Lahuipua'a on Hawai'i. The Lahuipua'a pond complex, however, is part of the Mauna Lani Resort, and the fish in the ponds are for enjoyment and education, not cultivation.

"In 1902, there were 99 ponds producing 682,464 lb. of fish; today (1994) we have six ponds State-wide yielding 31,639 lb. of fish" (Farber, 1997).

2003 **Period 6**

Only four fishponds are being used for aquaculture statewide – Mōli'i and Lokoea on O'ahu, LokoWaka on Hawai'i, and 'Ualapu'e on Moloka'i. Restoration efforts continue, but not without many obstacles. Government regulations, differing viewpoints on the purpose of historic preservation, and methods of restoration are key concerns. Beach access, coastal water quality and wetland protection, navigable rights, and public and private use are other issues that must be addressed. Kaloko pond on Hawai'i, Pa'ai'au, Huila, Waikalua, He'eia ponds on O'ahu and Ko'ie'ie pond on Maui are some of the fishponds currently in various stages of restoration.



Unit 3 at a Glance

Grades 9 - 12

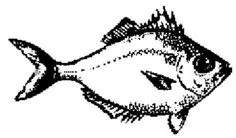
Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: Historical Empathy Apply knowledge of historical periods to assess present-day issues and decision- making.	**3F**. What can we learn from Hawaiian legends to guide us in making decisions about issues related to fishing today? **Activity:** ***Learning from the Past***	• Hawaiian legends provide insights to early Hawaiian life including the political structure, values, cultural protocol and practices. • Political, social, cultural and economic factors all influence decisions we make today about our fishing resources.	Students: • Complete concept maps that analyze factors affecting decision-making, comparing a Hawaiian legend to a current issue related to fishing. • Compare the issues covered in the concept maps and evaluate decisions that people make based on the political, social or economic conditions of the era.
Social Studies: Cultural Inquiry Use the research tools, procedures, and skills of anthropologists to develop informed positions on issues.	**3G**. What issues (past or present) have affected fishponds in my community? How could the perspectives and methods of a cultural anthropologist be applied to the study of an issue related to fishponds? **Activity: *Huli Kanaka***	• Developing informed positions on an issue related to fishponds requires research and thoughtful consideration of multiple perspectives.	Students: • Summarize data collected on an issue that has affected a local fishpond. • Explain how the methods and perspective of a cultural anthropologist are applied to their study of the issue.

Culminating Activity

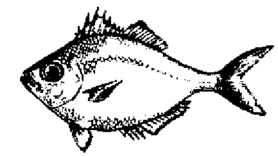
Students create position papers about an issue that has affected a local fishpond. Students share their position papers with one another and summarize the key points and the factors that they considered in taking a position. Students' papers should:

- provide a thoughtful description of the social or cultural issue (past or present), including the stakeholders and the perspectives that each brings to the issue;
- describe how students have applied the perspectives and methods of a cultural anthropologist; and
- defend their position with an in-depth explanation of how they arrived at their point of view.

Review criteria for assessing students' papers and have them work with you to develop a rubric (see sample rubric provided).



Sample Rubric for Culminating Activity



Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Social Studies: Cultural Inquiry Consider and describe a social or cultural issue (past or present). Examine the issue from the perspectives and methods of a cultural anthropologist. ***Points*** _____	Position paper describes the issue clearly, examines it from multiple perspectives, and describes methods of obtaining information based on cultural anthropology.	Position paper describes the issue clearly, and examines it from perspectives and methods of a cultural anthropologist.	Position paper describes the issue clearly, but does not examine the issue from the perspectives and methods of a cultural anthropologist.	Position paper does not describe the issue clearly or examine the issue from the perspectives and methods of a cultural anthropologist.
After analyzing data, develop a position paper on the issue. ***Points*** _____	Writing shows good evidence of analyzing data and includes an in-depth explanation of how position was reached. Writing shows exceptional analytical thinking.	Writing shows good evidence of analyzing data and includes an in-depth explanation of how position was reached.	Writing shows little evidence of analyzing data to reach a position. More information is needed.	Writing shows no evidence of analyzing data to reach a position.

I NOTICED:

Learning from the Past

- What can we learn from Hawaiian legends to guide us in making decisions about issues related to fishing today?

Hawaiʻi DOE Content Standard

Social Studies: Historical Empathy

- Students learn to judge the past on its own terms and use that knowledge to understand present-day issues, problems, and decision-making.

Grades 9 – 12 Performance Indicators

- Identify the historical period and relate it to a present-day issue.
- Describe the factors that influenced the people (of the historical period) in their decision-making.
- Evaluate decisions based on the political, social or economic conditions of the historical era.
- Identify the factors that influence decision-making on the present-day issues.

Key Concepts

- Hawaiian legends provide insights to early Hawaiian life including the political structure, values, cultural protocol and practices.
- Political, social, cultural and economic factors all influence decisions we make today about our fishing resources.

Activity at a Glance

Students analyze factors affecting decision-making in a legend about fishing and fishponds. They compare these factors with those affecting a present-day issue related to fishing in the Islands and participate in a demonstration about harvesting of fish.

Skills

reading, analysis, comparison, deduction

Assessment

Students:

- Complete concept maps that analyze factors affecting decision-making, comparing a Hawaiian legend to a current issue related to fishing.
- Compare the issues covered in the concept maps and evaluate decisions that people make based on the political, social or economic conditions of the era.

Time

2 class periods

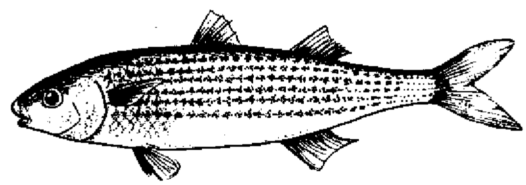
Vocabulary

Kū'ula - stone image of the fish god which could attract fish
ko'a - fishing grounds or shrine
sustainable use - use of a resource in a way that does not compromise the ability of future generations to meet their needs

Materials

Provided:
- student activity sheet
- student reading: *Kū'ula: God of Fishermen* (See *Whose Kuleana Is It Anyway?*, Unit 3, Gr. 6 - 8.)

Needed:
- a large clear bowl
- bag of peanuts or fish-shaped crackers
- news articles related to fishing (See Resources.)



Advance Preparation

During the week before conducting this activity, ask students to scan through the local newspaper each day and clip articles related to fishing. See Resources at the end of this lesson for a list of local newspaper Websites. A number of these sites offer search functions that allow users to research articles relevant to a topic. Make a copy of the student reading and two copies of the student activity sheet for each student.

Background

The legend *Kū'ula: God of Fishermen* provides insights into early Hawaiian life. By carefully reading the legend and using the concept map provided, students should discover the important values and ideas that the story conveys as well as the political, social and economic factors that were relevant at the time.

Important Values

- 'imi'ike (seek knowledge)
- mālama (care for)
- hō'ihi (respect)
- lokomaika'i (good hearted; generous)
- kuleana (responsibility)

Important Ideas

- Fishponds and fishing were important in sustaining the life of the community.
- If the chief who controlled the fishpond did not take good care of his people, he could meet an untimely end.
- It was very important to be generous; to share the catch from the sea and conserve the produce from the fishpond.
- It was important to respect the gods of fishing and make an offering of the first fish caught to the ko'a (fishing shrine).

Political Factors

The ali'i has full power. There is no trial or assumption that one is innocent until proven guilty.

Social Factors

Religion is important; many ko'a (fishing shrines) are built and people make offerings and pray to Kū'ula. People cooperate and share with one another and show loyalty to Kū'ula, acknowledging his generosity.

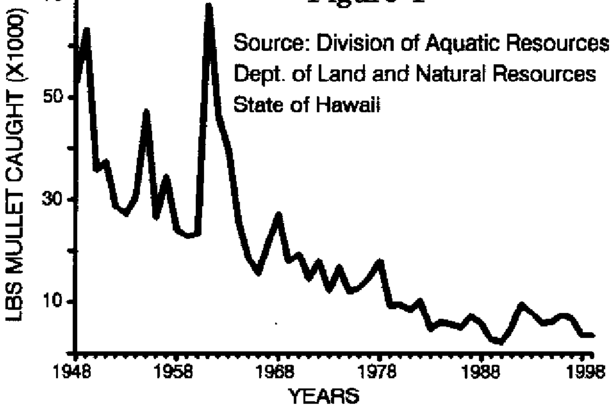
Economic Factors

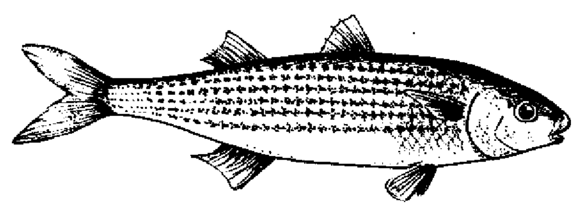
There is a subsistence economy where people catch fish and grow food for their survival. People exchange and share resources; there is no money involved in transactions and no ownership of land. Sustainable fishing (harvesting only what is needed) is a way of life.

In contrast to the legend, fishing issues in the Islands today also revolve around competition for fish and scarcity of resources, but rather than a hungry eel, the "culprits" are a variety of human activities including over-fishing, pollution, and destruction of fish breeding and nursery grounds. The political, social and economic factors have changed considerably as well. Regulatory agencies such as the Hawai'i Division of Aquatic Resources and the Western Pacific Regional Fisheries Council are charged with monitoring fishing resources and enforcing fishing regulations. And even though the economic system has changed from subsistence to a market economy, there are still issues related to balancing the needs of subsistence fishers with those who fish commercially. Balancing those needs is becoming increasingly difficult with the decline in local fisheries.

An example of the decline in the local fisheries is summarized in Figure 1 showing the commercial landings of the 'ama'ama (striped mullet) since 1948. The 'ama'ama is one of the prominent fish species in Hawaiian fishponds and fishing lore. The mullet fishery has been managed since ancient times by placing a kapu (taboo) on their collection during the months they spawn (December through February). That kapu is still in place today. Despite the regulations, over-fishing and the destruction of the nursery habitat have severely impacted the commercial landings of 'ama'ama and other nearshore fisheries.

Figure 1





'Ama'ama (striped mullet) is also known as "pua'a kai" (sea pig) and was used in Hawai'i for ritual offerings when a pig was not available.

Source:
Division of Aquatic Resources, 1999. Department of Land and Natural Resources, State of Hawai'i: <dlnr_aquatics@exec.state.hi> (March 14, 2003). http://www.state.hi.us/dlnr/dar/fish_stats.htm

Teaching Suggestions

1. Read the legend *Kū'ula: God of Fishermen* or select a different legend from the Resources listed at the end of this activity.

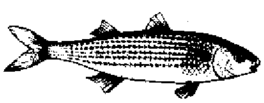
2. As students read the legend, have them locate key sites on a map of Maui. (If you have a copy of *Hawaiian Fishing Legends*, refer to the map of the sites provided in the back of the book.)

3. Distribute the student activity sheets and ask students to create a concept map for the legend they have just read.

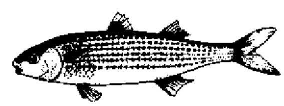
4. Discuss the key elements that students have identified on their concept maps.

   Discussion Questions
   - What did you learn about fishing and fishponds in this legend?
   - Which people, places and events did you identify as significant? Why?
   - What are the most important values conveyed in this legend?
   - Why do you think an eel was portrayed as the one who stole the fish?
   - Which political, social or economic factors did you identify as being important? Why?
   - Does your family practice traditions related to fishing? If so, what are they?
   - How do these practices maintain the culture of fishing?

5. Ask students to describe what they believe to be a significant issue related to fishing today. Discuss the decline in the local fisheries and introduce a demonstration about harvesting fish.



Fish Harvest Demonstration*



- Place a large clear bowl in a central area of the classroom and identify it as the community's local fishing grounds. Fill the bowl with 16 "fish" (peanuts or fish-shaped crackers).

- Divide the class into four teams and explain the harvesting rules. (Don't emphasize conservation with the teams, let them work on maximizing points if that is their goal. Conservation will become crucial if the fishing area is overfished.)
  - There will be four harvesting periods, each lasting 30 seconds.
  - During the harvest, all teams harvest at once (catching all of the fish, some of the fish, or none.)
  - For every three fish that a team harvests, the team receives 1/4 point.
  - For every three fish remaining in the ocean after each harvest, one fish will be added, up to a total of 16 fish in the fishing grounds.

- After each harvesting period, add up team points and restock the ocean, if adequate numbers of fish remain. After the fourth harvest, discuss what happened in the demonstration.

*Demonstration adapted from "The Commons Dilemma," *Living Lightly on the Planet*, National Audubon Society, 1985.

Discussion Questions

- Was the fishing area overfished?
- What was the best strategy for harvesting from this resource? (*If each team harvests two fish at each trial, the teams each earn two points by the end of the four trials and the fishing area retains a population of 16 fish when the harvest is over.*)
- What does sustainable use of a resource mean? (*Using the resource in a way that does not compromise the ability of future generations to meet their needs.*)

6. Have students select one of the news articles from those that students have collected and analyze a fishing issue that affects people on their island today. Ask them to complete a concept map for the issue and then complete the assessment activity.

7. How did students evaluate the decisions that people made based on the political, social or economic conditions of the different eras? If decisions have not been made on the current issue they are analyzing, how might these factors affect decisions? Discuss their ideas.

Adaptations/Extensions

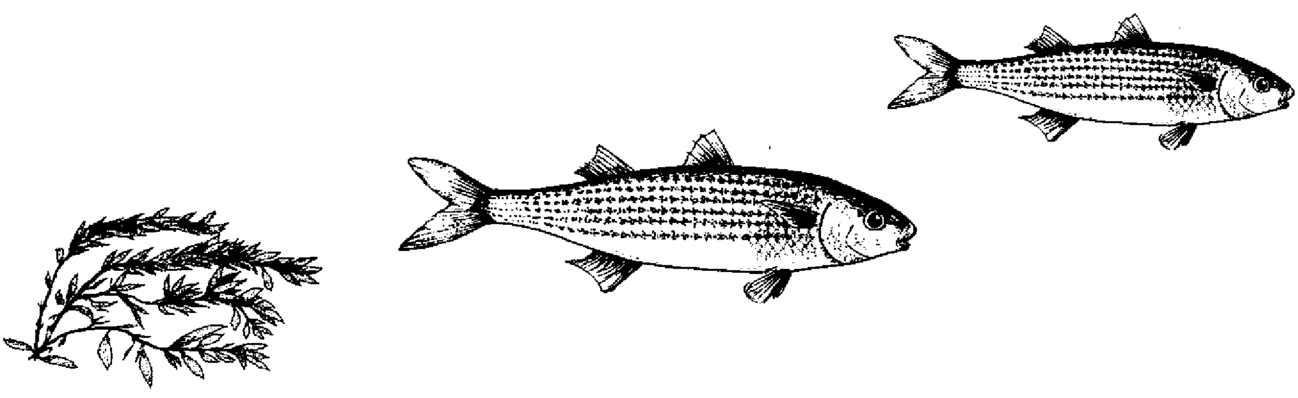
- Create a large map featuring the areas described in the legend. Have students create drawings and notes from their concept maps to stick onto the map and post it in the classroom.

- Conduct a field trip to visit the sites featured in the legend. At each site, point out important physical features or landforms and have students close their eyes and visualize while someone retells the part of the story relevant to the site. Ask a kupuna about oli (chants) associated with the area and have students learn one. Allow time for students to find a quiet place to write a reflection in a journal before returning to the bus.

Resources

Beckwith, Martha. 1970. *Hawaiian Mythology*. University of Hawaiʻi Press. Honolulu, HI.

Kawaharada, Dennis. (Editor). 1999. *Hawaiian Fishing Legends*. Kalamakū Press. Honolulu, HI.



Hawai'i Newspaper Websites

Daily

Hilo	Hawaii Tribune-Herald	http://www.hilohawaiitribune.com/
Honolulu	Advertiser	http://www.honoluluadvertiser.com/
	Star-Bulletin	http://starbulletin.com/
Kailua-Kona	West Hawai'i Today	http://www.westhawaiitoday.com/
Līhuē	Garden Island	http://www.kauaiworld.com/
Wailuku	Maui News	http://www.mauinews.com/

Business

Honolulu	Pacific Business News	http://pacific.bizjournals.com/pacific/

Non-daily

Kāne'ohe	Sun Press Midweek	http://www.midweek.com/mwshell.htm
Lahaina	News	http://www.westmaui.com/
Makawao	Haleakalā Times	http://www.mauisfreepress.com/
Maunaloa	Dispatch	http://www.aloha.net/~mkkdisp/
Moloka'i	Advertiser News	http://www.gine.com/man/molokai_advertiser.htm
O'ahu	North Shore News	http://www.northshorenews.com/

Alternative

Honolulu	Downtown Planet	http://www.downtownplanet.com/indexa.html
	Honolulu Weekly	http://www.honoluluweekly.com/
Maui	Aloha News	http://alohanews.com/

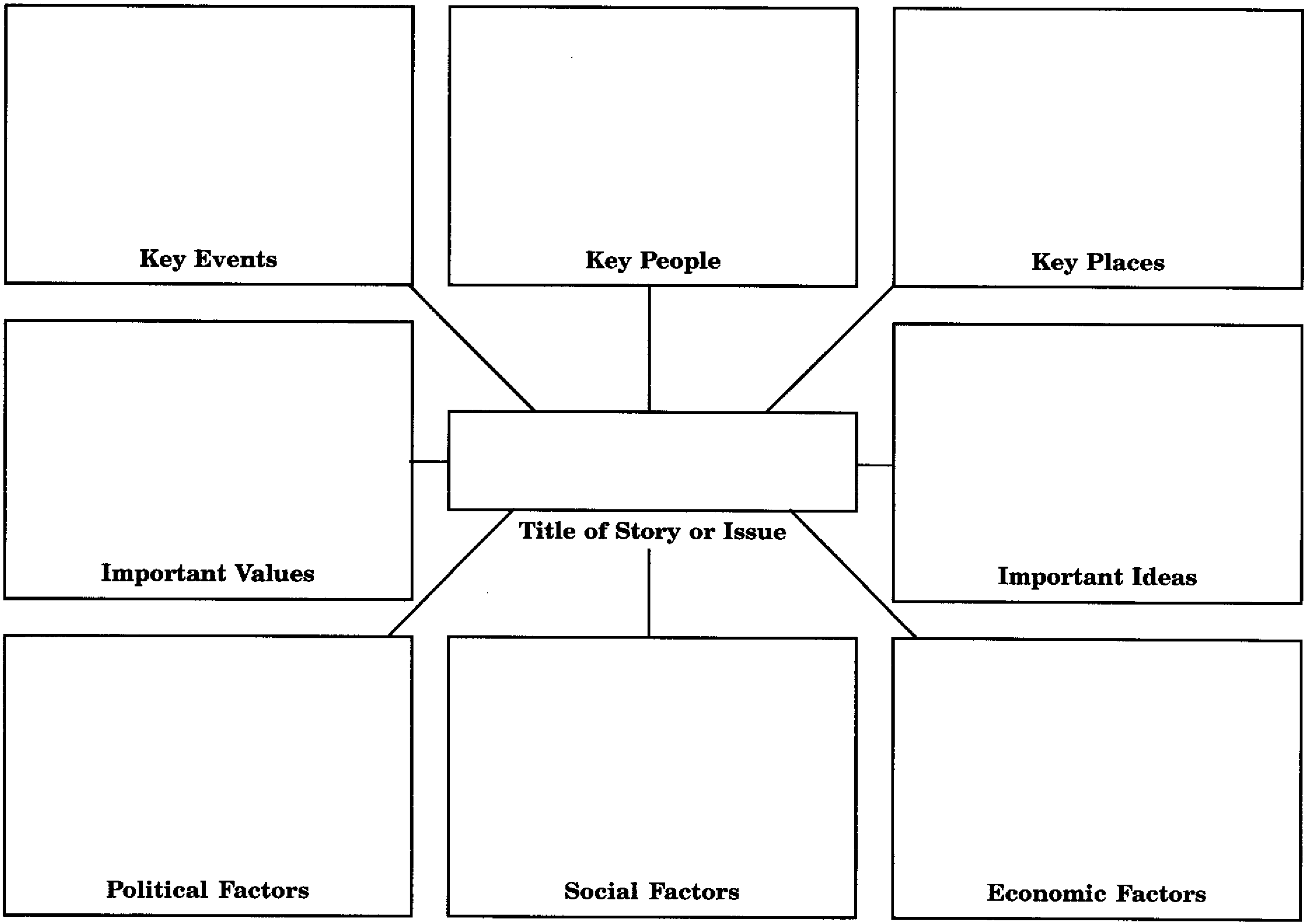
Campus

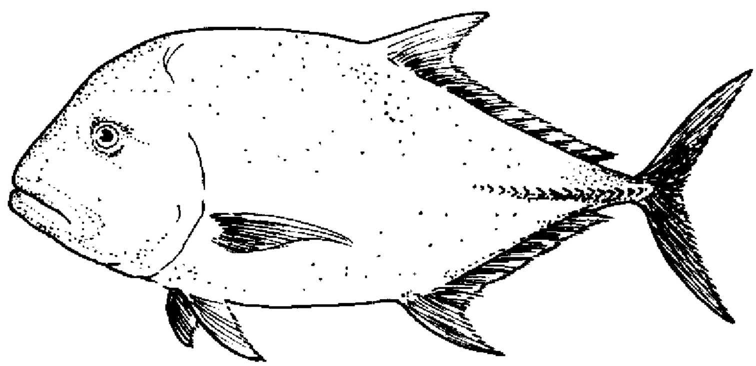
Brigham Young	Ke Alakai	http://www.byuh.edu/kealakai/
U.H. Mānoa	Ka Leo O Hawai'i	http://www.kaleo.org/

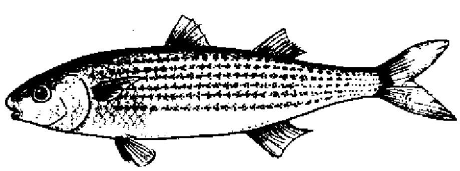
Student Activity Sheet

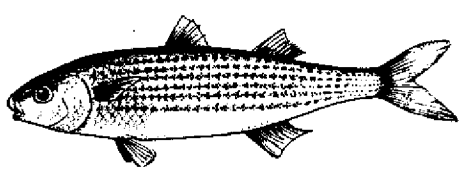
Name________________________

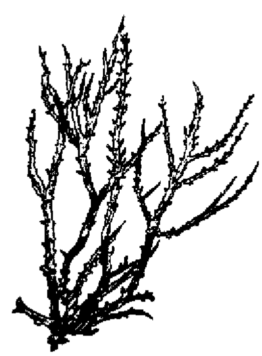
Concept Map











Huli Kanaka

- What issues (past or present) have affected fishponds in my community? How could the perspectives and methods of a cultural anthropologist be applied to the study of an issue related to fishponds?

Hawaiʻi DOE Content Standard

Social Studies: Cultural Inquiry:
- Students use the tools and methodology of social scientists to explain and interpret ideas and events.

Grade 9 - 12 Performance Indicators

- Consider and describe a social or cultural issue (past or present).
- Examine the issue from the perspectives and methods of a cultural anthropologist.
- After analyzing data, develop a position paper on the issue. (culminating activity)

Key Concept

Developing informed positions on an issue related to fishponds requires research and thoughtful consideration of multiple perspectives.

Prerequisites

Fishpond Fall, Unit 3, Grades 6 – 8; *Learning from the Past*

Activity at a Glance

Students employ the methods of a cultural anthropologist to collect information about an issue that has affected a local fishpond.

Time

3 class periods

Skills

reasoning, analysis, writing, communicating

Assessment

Students:
- Summarize data collected on an issue that has affected a local fishpond.
- Explain how the methods and perspective of a cultural anthropologist are applied to their study of the issue.

Vocabulary

huli kanaka – profound studies of any kind, moral philosophy, science; anthropologist
ethnocentric – having race as a central interest; assuming one's group to be superior
cultural anthropologist – someone who studies human social and cultural systems, particularly customs, values and beliefs of a culture
hīhīmanu – stingray
olonā – a native plant that Hawaiians used to make very strong fibers for lashing materials together

Materials

Provided:
- The story of *Lupe Kia'i Nui*

Needed:
- Resources listed at the end of this activity

Advance Preparation

Make enough copies of the mo'olelo *Lupe Kia'i Nui* for each student. Work with the school librarian to collect some of the materials listed in the Resources at the end of this activity.

Background

Cultural anthropologists study human social and cultural systems, particularly customs, values and beliefs of a culture. They may compare different societies and cultures (past or present) or study their own culture to learn more about family and group relationships. The perspective of the cultural anthropologist is well-rounded and cross-cultural to reduce a human tendency to be ethnocentric. The cultural anthropologist is trained to gather knowledge of a people's history, to demonstrate empathy for different groups, and to appreciate indigenous solutions or strategies.

Cultural anthropologists use various methods to study cultural systems including interviewing, gathering records, and conducting field studies, some of which involve living with a different culture. Cultural anthropologists work to acquire good interviewing skills such as the ability to listen, to pay attention to details, and to allow the person being interviewed to determine what the important questions are.

Teaching Suggestions

1. Have students read the mo'olelo *Lupe Kia'i Nui.* Identify the issue surrounding the fishpond. How was the issue resolved?

2. Remind students that legends were a form of oral communication for early Hawaiians. Mo'olelo provided insights to the culture and traditions of the ancient kūpuna (ancestors). Through legends, early Hawaiians were able to instill values in the younger generation and to resolve issues – as in the mo'olelo *Lupe Kia'i Nui.*

3. Write the following question on the board:

What issues (past or present) affect the fishpond in my community?

4. If students are unfamiliar with any current issues, review the prerequisite activity, *Fishpond Fall*, which introduces issues that have affected fishponds in the past. Have the class as a whole agree on an issue to study or ask individual students to select an issue to pursue.

5. Introduce the role of cultural anthropologists. Discuss the perspective of cultural anthropologists and the methods that they use to study cultures. Introduce the idea of ethnocentrism and discuss ways that students can develop empathy for different groups.

6. Challenge students to assume the role of a cultural anthropologist as they research an issue related to a local fishpond. Ask them to collect information in the community, conduct library research and analyze the information they have collected. They may want to use the concept map introduced in the activity *Learning from the Past* to help them organize their ideas.

7. Have students complete the assessment activity, summarizing the data they have collected and explaining how the methods and perspective of a cultural anthropologist were applied to their study of the issue.

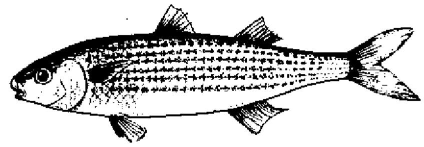
8. Ask students to take a position on the issue and write a paper that describes the issue and supports their position. (See culminating activity in Unit at a Glance.)

Adaptations/Extensions

- Have students conduct research to learn more about careers in cultural anthropology. See: Kiwi Careers. *Anthropologist*. (Copyright © 1998 - 2002, Career Services.) http://www.careers.co.nz/jobs/13b_soc/j26321a.htm. The site has personal information from anthropologists relating what they do in their careers and the type of education they pursued.

- Invite community members to come to the school and share their perspectives about the issue with students.

Island Fishpond References



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Shelly & Deidra. 1997. *Menehune Fishpond.* (Copyright © 1997 King Kaumuali'i Elementary School) <criof456@k12.hi.us> http://www.hern.hawaii.edu/~laakea/class/maikai/fishpond.html

O'ahu

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Kelly, Marion. 1975. *Loko I'a O He'eia: He'eia Fishpond.* Bernice Pauahi Bishop Museum. Honolulu, HI.

State of Hawai'i Office of State Planning. 1992. *Kāne'ohe Bay Master Plan by the Kāne'ohe Bay Master Plan Task Force.*

Molokaʻi

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Maui

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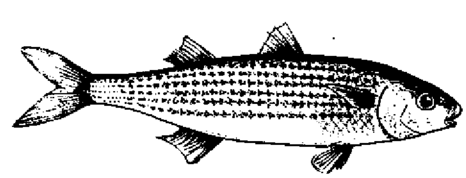


Student Reading

Lupe Kia'i Nui

The konohiki of He'eia Fishpond asked the help of the stingrays that lived at Kekepa island near Mōkapu to watch over his pond. He paddled his canoe to the island and prayed to the god of the hīhīmanu (stingrays) to help him protect the fish in his pond.

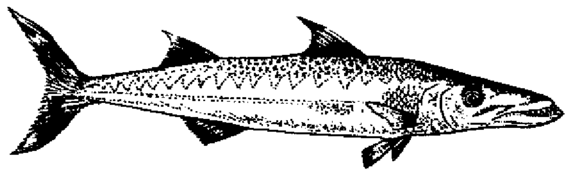
"Oh hīhīmanu akua, I need you to help save my crop of 'ama'ama (mullet). The kākū (barracuda) and 'aihue loko (pond robbers) are stealing all my fish. I will do anything to get your help."

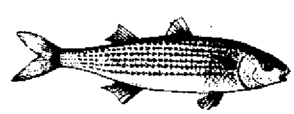
The hīhīmanu akua replied. "I want you to promise me that your fishpond will always be a fishpond and will be a fishpond for your children and for their children and for their children forever."

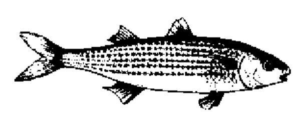
"'Ae, 'ae," the konohiki answered. The super-watching stingray Lupe Kia'i Nui then pulled the konohiki in the canoe back to the pond by flying in the sky like a kite. The kite string made of olonā was over a mile long.

Lupe Kia'i Nui then made his home near the mākāhā. From this spot, he could watch the fishpond walls and all that happened inside the pond. He could swiftly fly to any spot when he sensed a predator or intruder. If there were many intruders or predators, he would call to his friends at Kekepa for help. Lupe Kia'i Nui would kill and eat the predators such as the kākū. If human pond robbers were seen, he would slash them to death with his tail.

To this day, He'eia Fishpond is still a fishpond, so the konohiki kept his word. At times during the year, the waters of the pond will sparkle and glow in the night as it is whipped and lashed by the legendary hīhīmanu chasing the kākū.





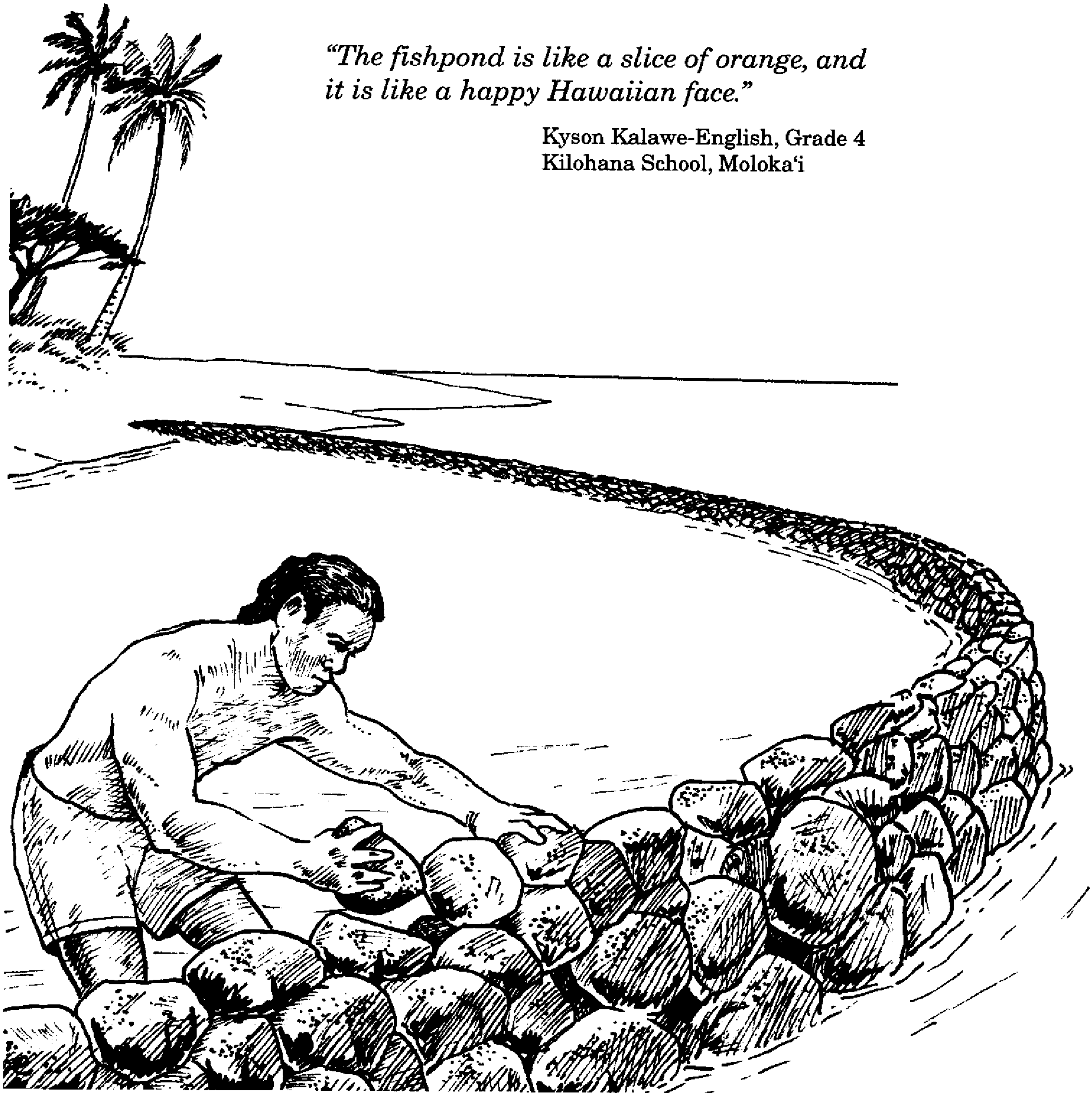


Summarized from Sterling, Elspeth P. and Catherine C. Summers. 1978. *Sites of Oahu.*

UNIT 4
Hawaiian Fishponds Today

"The fishpond is like a slice of orange, and it is like a happy Hawaiian face."

Kyson Kalawe-English, Grade 4
Kilohana School, Moloka'i



Hawaiian Fishponds Today

"Ho'ulaulima [sic] ku na kūpuna,
mālama no ka loko i'a **ho'omau neia waiwai ho'oilina.**
- Let us work in the manner of our ancestors,
let us preserve the fishpond to continue this part of our heritage."

Lehman L. (Bud) Henry (1993)

Loko kuapā (fishponds with rock seawalls) were developed for the specific purpose of sheltering and nurturing fish for consumption as early as the 13th century in Hawai'i. A feature of these shoreline fishponds unique to the Hawaiian Islands is the placement of one or more sluice gates or grates (mākāhā) in the fishpond wall (Kikuchi, 1973). Massive fishpond walls still standing after centuries of wind and waves are silent testimony to the engineering feat that Hawaiians achieved. Although fishponds played an important role in the lives of early Hawaiians, today only a handful are in use. What led to decline of fishponds and what is the potential for restoring these cultural treasures?

Decline of Fishponds

When the Kingdom of Hawai'i became a Territory of the United States at the beginning of the twentieth century, about 100 of the estimated 488 original fishponds were still in operation (Farber, 1997). Although the surface area of the active ponds decreased to about half of what it had been a century earlier, production dropped to a third of that estimated at the time of European contact with the Islands. Seventy-five years later, in 1975 to 1976, the State of Hawai'i recorded less than 10,000 kg of total production from all fishponds or only 1% of the pre-European contact production (Tamaru and Carlstrom-Trick, 1998).

The causes of decline are many, but key among them are destruction of pond walls ordered by ruling chiefs during war, decimation of the native population due to introduced disease, and the sandalwood trade which, by order of the chiefs, drew many able-bodied men and women to the forest to harvest wood. Changes in land tenure as a result of the Great Mahele of 1848 also played a key role in the decline of fishponds. There was a total loss of pond management practice due to the transfer of the authority of the chief and king to the bureaucracy of the elected and appointed government. Benign neglect and lack of repair of damaged wall and gate structures caused by natural events such as storms, tsunamis, and lava flows also led to pond deterioration. Today, many valuable oceanfront properties are built atop fishponds that were filled in by housing developers.

Restoration Efforts

Physical restoration and revitalization efforts of some Hawaiian fishponds began during World War II in an attempt to produce food for increasing civilian and military populations. In addition to those efforts, there have been several major surges in restoration activities:

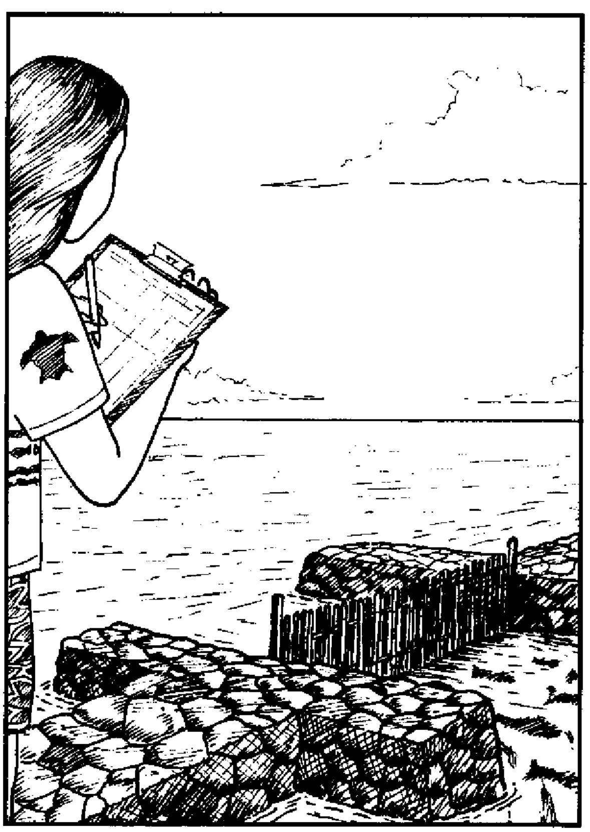
1965: Rockefeller Foundation; 12 fishponds on Moloka'i.

1986-90: Department of Historic Preservation, Maui County and the Hawai'i Department of Business Economic Development and Tourism; two fishponds on Moloka'i.

1991-1993: Farmers Home Administration and U.S. Department of Agriculture; two fishponds in Hāna, Maui.

1995-current: U.S. Department of Agriculture and Hawai'i Department of Labor and Industrial Relations: at least four fishponds on Moloka'i (Tamaru and Carlstrom-Trick, 1998).

Loko i'a played an important role in the lives of early Hawaiians. Yet today, it is a challenge for the few who are involved in fishpond production for the economic climate has changed.



Hawaiian pond culture systems were developed in a subsistence economy where labor had no cost and where the primary function of the loko kuapā was the storage of fish for the benefit of the ali'i.

Efforts are being made to restore and place in service several fishponds both as sustainable development demonstrations and as opportunities to maintain ties to an important element of cultural heritage.

Educational Tools

The early Hawaiians' extensive understanding of their environment is evidenced by the integrated agricultural/aquaculture complex that today is symbolized by the loko kuapā. Rediscovering ways to be in tune with the, sun, moon, tides, fish, crustaceans, and algae may prove to be more important to our children than the monetary value of any fish produced from these ancient structures.

Using the ancient fishponds as educational tools is a way to teach and preserve the culture of the early settlers of Hawai'i. Reflecting on the past is also a way to help us set our course for the future. The Hawaiian saying "*He ali'i ka 'āina; he kauwā ke kanaka.* The land is a chief; man is its servant" is translated by Mary Kawena Pukui (1983) to mean that "Land has no need for man, but man needs the land and works it for a livelihood." What can we learn from the ways that the early Hawaiians responded to their environment? Which of their practices are still relevant today as we seek to mālama i ka 'āina?

Humankind is becoming aware that our world is not one of infinite resources. The following message stated almost 150 years ago, has been largely ignored by modern society:

...You must teach your children that the ground beneath their feet is the ashes of your grandfathers...so that they will respect the land... Teach your children...that the earth is our mother. Whatever befalls the earth befalls the sons of the earth.

...This we know; the earth does not belong to man, man belongs to the earth...Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web; he does to himself.

- Native American Chief Seattle (1854)

In the fast-paced societies of today, movements to understand and preserve the mores of the past are becoming widespread. The Native Hawaiian renaissance, begun passionately in the 1970s, is bringing awareness that that past holds key information that is critical to how we carry on in the future.

Apparent in prayers and oli passed down through the generations, the early Hawaiians viewed their world as a gift from the gods. Nature, in all its glory, was to be loved, respected and cared for. In our efforts to mālama i ka ʻāina, we must preserve also the physical evidence of the past such as the loko iʻa, structures that have clearly withstood the test of time. By allowing them to become our classrooms, we can almost hear the chanting, the clunking of stone upon stone, the groans of the early Hawaiians as they passed the heavy stones one-by-one to each fishpond site. It is within this setting that students can truly begin to appreciate the science, language arts and social traditions mastered by the early Hawaiians.

Me nā mea ʻoi loa mai nā wā mamua, o holomua kākou i kēia au
Ua hiki mai ka wanaʻao no ka hoʻōla a me ka hoʻāla hou.

Let us move forward to the future carrying with us the best from the past. The time has arrived for the revitalizing and reawakening of our community.

– S. Haunani Apoliona (1991)

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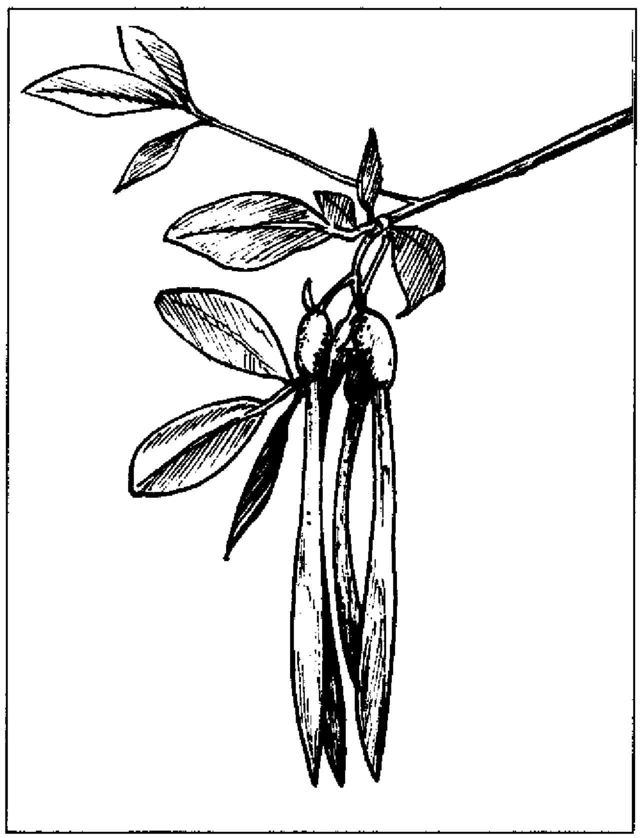
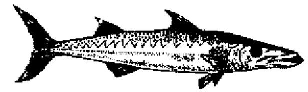


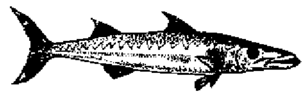
Mangrove is an introduced plant now common in many Hawaiian fishponds.

Unit 4 at a Glance



Grades 4 - 5

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: Living the values, attitudes and commitments of the inquiring mind Students apply the values, attitudes and commitments characteristic of an inquiring mind. **Science: Mālama I Ka ʻĀina** Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.	**4A.** How are fishponds today different from fishponds in early Hawaiʻi? **4B.** How are fishponds cared for today and why is it important to conserve these resources? **Activity:** ***Exploring a Fishpond***	• Hawaiian fishponds have changed over time. Fishponds today have some new alien species of plants and animals, mākāhā made of modern materials (some have movable gates), and impacts from human development. • Hawaiian fishponds being restored today are managed for education, food production, and the conservation of cultural and natural resources. • Communities are involved in caring for fishponds by restoring pond walls, removing alien species, and teaching others about the pond's significance.	Students complete learning logs with: • questions they have formulated and information they have gathered; • a description of how the fishpond they visited is different from an early Hawaiian fishpond; and • a summary of how the fishpond is cared for today and why it is important to conserve natural and cultural resources.



Unit 4 Culminating Activity

Unit 4 is a culminating activity that builds on activities presented in Units 1 – 3 and focuses on a visit to a fishpond. Students develop learning logs with the following information:

- questions they formulate and information they have gathered at the fishpond;
- a description of how the fishpond they visited is different from an early Hawaiian fishpond; and
- a summary of how the fishpond is cared for today and why it is important to conserve natural and cultural resources.

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Science: Living the values, attitudes and commitments of the inquiring mind Ask questions to expand an idea or statement. ***Points*** _____	Questions indicate critical thinking and blending of ideas from previous units, leading to further knowledge of different ways fishponds have changed from early Hawaiʻi to today.	Questions expand on ideas and lead to further knowledge of different ways fishponds have changed from early Hawaiʻi to today.	Questions lead to some information about ways that fishponds have changed from early Hawaiʻi to today, but more thinking is needed.	Questions are unclear, irrelevant (don't apply to the subject), or too simplistic to expand on ideas and lead to further knowledge.
Science: Mālama I Ka ʻĀina Examine (and explain – Gr. 5) why there is a need to conserve natural resources. ***Points*** _____	Writing accurately summarizes how the fishpond is managed and cared for today and provides thoughtful ideas and examples to illustrate why it is important to conserve resources.	Writing accurately summarizes how the fishpond is managed and cared for today and presents well-developed ideas about why it is important to conserve resources.	Writing is accurate, but needs more information to explain how the fishpond is managed and cared for today and/or why it is important to conserve resources.	Writing is unclear and needs more information or examples.

I NOTICED:

Exploring a Fishpond

- How are fishponds today different from fishponds in early Hawai'i? How are fishponds cared for and why is it important to conserve these resources?

Hawai'i DOE Content Standards

Science: Living the values, attitudes and commitments of the inquiring mind:
- Students apply the values, attitudes and commitments characteristic of an inquiring mind.

Science: Mālama I Ka 'Āina: Sustainability
- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 4 - 5 Performance Indicators

Grade 4
- Ask questions.
- Ask questions to expand an idea or statement.
- Examine why there is a need to conserve natural resources.

Grade 5
- Ask questions.
- Ask questions to expand an idea or statement.
- Examine and explain why there is a need to conserve natural resources.

Key Concepts

- Hawaiian fishponds have changed over time. Fishponds today have some new alien species of plants and animals, mākāhā made of modern materials (some have movable gates), and impacts from human development.
- Hawaiian fishponds being restored today are managed for education, food production, and the conservation of cultural and natural resources.
- Communities are involved in caring for fishponds by restoring pond walls, removing alien species, and teaching others about the pond's significance.

Prerequisites

At least one activity from each of Units 1 - 3

Activity at a Glance

Students investigate a fishpond to learn more about the physical features, the life in the pond, and human activities at the pond—past and present.

Time

2 class periods and a field day at the fishpond

Skills

observing, formulating questions, reasoning, analyzing, writing

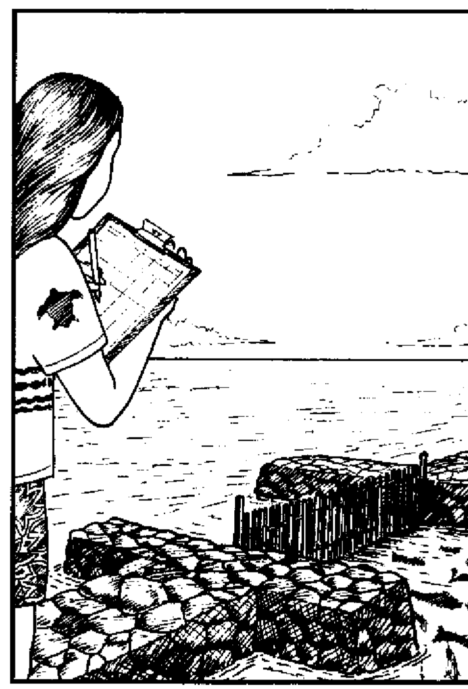
Assessment

Students complete learning logs with:

- questions they have formulated and information they have gathered;
- a description of how the fishpond they visited is different from an early Hawaiian fishpond; and
- a summary of how the fishpond is cared for today and why it is important to conserve natural and cultural resources.

Vocabulary

ʻāina – land, environment
aloha ʻāina – love for the land
conservation – wise use; protection that prevents exploitation or destruction
hōʻihi – respect
laulima –cooperation; working together
mālama – care for



Materials Needed

Provided:

- fishpond hunt log

Needed:

- clipboards (one per group)
- rubber bands to secure papers to clipboard
- pencils
- notebooks for learning logs

Advance Preparation

Schedule a field site visit to the fishpond. Contact the curriculum coordinator or a person on your island (see Appendices) to make arrangements for your visit. The coordinator will help schedule a date for your class to visit the fishpond and line up resource people to be available on the day of your class visit. The coordinator will provide you with a list of supplies you may need and assist you with any other inquiries. Be sure to:

- Send home field trip permission slips along with a note to parents about what students will need.
- Evenly divide the class into four smaller groups to rotate through learning hui (stations) at the pond.
- Make one copy per group of the fishpond hunt log provided with this activity.

Before Visiting the Fishpond

1. Write the following statement on the board and ask students to come up with ideas to complete it:

   "Hawaiian fishponds have changed over time. Fishponds today have…"

2. Discuss students' ideas and challenge them to generate questions that would help them to complete the statement. (Save their questions for #6 below.)

3. Tell students that the class will be visiting a fishpond and explain that there will be resource people on site to answer questions and to help them explore at different learning stations. Review the stations and the key concepts that will be covered:

   - The Ahupua'a – the physical environment: stories and human impact in the ahupua'a where the fishpond is located
   - Life in the Pond – organisms (native and alien) that live in the fishpond today
   - The Mākāhā – how the mākāhā functions and how it is different from an early Hawaiian mākāhā
   - Plants and Mo'olelo – the cultural connections to fishponds and how we care for the pond today

4. Divide the class into four groups and explain that students in each group will work together on a fishpond hunt. Distribute a fishpond hunt log to each group.

5. Have students review the log and select a "Recorder." This student will be responsible for recording answers onto the fishpond hunt log while students are at the fishpond. Each student within the group is responsible for gathering information from each learning station and assisting his/her group's "Recorder" in recording the answers.

6. Have students list their questions on the backside of the fishpond hunt log and have them determine who will ask each question during the field investigation.

7. Explain that the fishpond hunt log will be turned in after the field site visit and that the information collected will help students to create individual learning logs. Discuss what is expected in the assessment for this activity and if desired, have students work on a rubric that will be used in the assessment. (See sample rubric provided with this unit.)

8. Discuss safety precautions and values that are important for a good field experience, such as hōʻihi (respect) and mālama (care for) the environment and one another.

Investigations at the Pond

9. At the fishpond, students will participate in four learning stations. The time at each station will last approximately 30 minutes.

    - Remind students to ask their questions at each station and for the "Recorder" to take notes and record the team's evidence.
    - Encourage students to take photographs (if desired) to help with their learning logs.

After Visiting the Fishpond

10. Discuss students' observations from the field trip and their ideas about conserving fishponds.

    Discussion Questions
    - What is the most interesting thing you have learned about fishponds?
    - What responses to your questions did your group receive from resource people at the pond?
    - What would you still like to learn to further your knowledge of fishponds? How might you find this information?
    - How have people had an impact on Hawaiian fishponds?
    - Do you feel it is important to restore and conserve fishponds today? Why or why not?
    - What does "Mālama I Ka ʻĀina" mean to you?

11. Ask students to complete the assessment activities.

Adaptations/Extensions

- Re-visit the K-W-L chart from Unit 1 and have students fill in what they have learned.

- Convert your classroom into a "fishpond" and invite other classes to come in for guided tours. Students could use cardboard or butcher paper to make rock walls and ʻauwai. Small branches and wire could be used to construct mākāhā. To add pond life, encourage students to create three-dimensional animals using the pond life cards. Duplicate copies can be colored, cut, stuffed and hung or displayed around the "pond" in the appropriate habitat. Educational labels should accompany each animal and each feature of the pond.

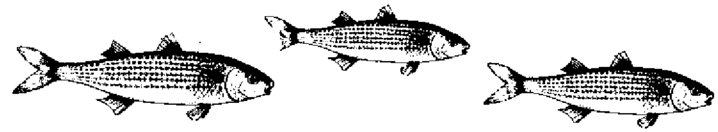
- Work with your school community to schedule days to mālama the fishpond. Contact the person or agency that oversees the fishpond and develop plans for service projects such as litter control and pulling mangrove. Have students document the progress made with "before" and "after" photographs.

- Make posters with captions about caring for fishponds and post them in a public area such as a library or mall. Students may also reduce their posters to postcard size and mail to 'ohana (family) and friends with their messages.

- Have students produce a PSA (public service announcement) about caring and restoring fishponds. Facilitate the production process by identifying roles such as camera crew, director, writer, and talent. Help students with the concept idea and storyboard. Submit the project to cable television for airing.

Note: Please share samples of your students' work with Project Kāhea Loko for posting on the project's Website. The Website address is: www.thepaf.org. Mahalo!

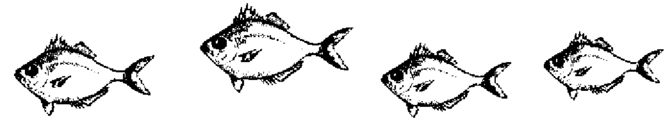
Fishpond Hunt Log



Name: ____________

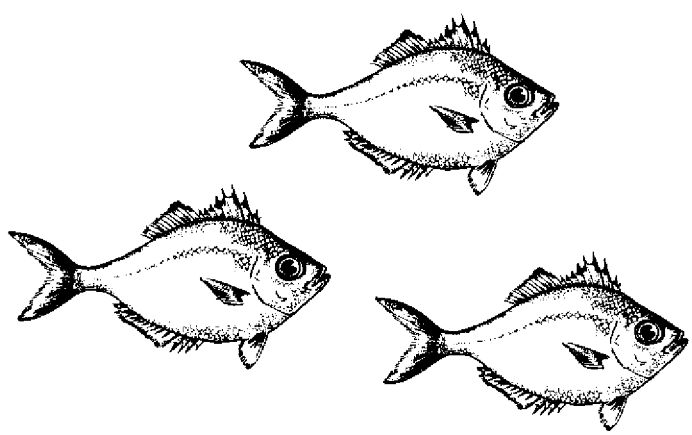
Station 1 The Ahupua'a	Your Evidence	Station 2 Life in the Pond	Your Evidence
Find the fresh water stream(s) that flows (or once flowed) into the fishpond.		Find a producer that lives in the pond. (Hint: It makes its own food using the sun's energy.)	
Find the highest peak in the ahupua'a.		Find the kind of fish that the ali'i usually harvested from the pond.	
Summarize the mo'olelo (story) about this area.		Find a big carnivore in the pond.	
BONUS Describe aloha 'āina (love for the land) and how this value helps to maintain a healthy ahupua'a.		**BONUS** Describe how the value hō'ihi (to respect) can be applied to the plants and animals that live in the fishpond.	

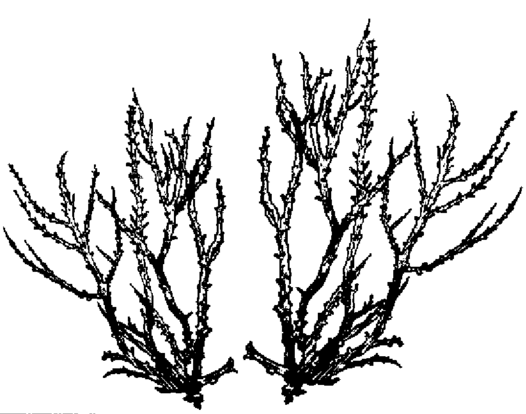
Fishpond Hunt Log



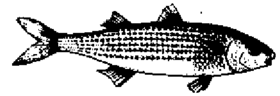
Name: ____________________

Station 3 The Fishpond	Your Evidence	Station 4 Mālama	Your Evidence
Find a major current in the pond. (Is the tide coming in or going out?)		Find a name of a mo'o wahine (guardian lizard) who watches over a fishpond. Why were these mo'o significant?	
Find out how Hawaiians built loko kuapā.		Find a plant that was here before people. (How do you think this native got here?)	
Find the mākāhā. (How would you use the mākāhā to catch fish?)		Find a plant that is out of balance with the fishpond and explain how it reached Hawai'i.	
BONUS Why is laulima (to cooperate) an important value in the building of a fishpond?		**BONUS** Describe how you would mālama (care for) the fishpond.	





Unit 4 at a Glance



Grades 6 - 8

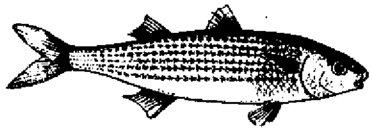
Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Social Studies: Citizenship / Participation Explain the significance of citizenship and participate responsibly for the common good, for example, select and study an issue or problem and plan and implement civic action.	**4C.** What are your beliefs and values regarding the conservation of fishponds in Hawai'i? How do we participate responsibly in civic actions? **Activity:** ***De-bait Goes On***	• Issues related to the conservation of fishponds involve different perspectives depending on the values and beliefs of the people involved. • People in a community have a responsibility to identify and evaluate solutions to issues, such as fishpond conservation, based on recognition of their own and others' values and beliefs.	Students write a summary that: - explains the roles and responsibilities of citizens involved in the debate; - describes the importance of participation in civic actions for the benefit of society; and - clarifies their own personal values related to the issue of fishpond conservation.
Social Studies: Citizenship / Participation Explain the significance of citizenship and participate responsibly for the common good, for example, select and study an issue or problem and plan and implement civic action.	**4D.** How have human activities affected the environment of the fishpond? In what ways can students become involved in stewardship of fishponds today? **Activity:** ***Mālama Loko I'a***	• Hawaiian fishponds are affected by a number of human activities including those that cause soil erosion, stream alteration, water pollution, and the introduction of alien species. • Activities to mālama (care for) fishponds may include helping to restore physical features of the ponds, preventing pollution of streams and coastal waters, helping to remove alien species, and planting native plants. • Fishponds in Hawai'i are valuable cultural resources that are being restored and managed for food production, educational enrichment and to reconnect people to the life of the land.	Students: • Write a summary of the ways that human activities have affected the environment of the fishpond. • Work in small groups to propose a project that would demonstrate mālama (caring for) the pond.

Culminating Activity

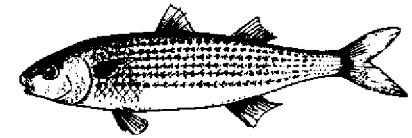
Students work in small groups to develop action plans to mālama the fishpond they have been studying. Their action plans should include:

- The problem that they have identified
- Who is affected by the problem and the value systems that are important in their solution
- Steps they will take to help solve the problem

Note: Students should then submit evidence to show how they have implemented their action plans!
Review criteria for assessing students' action plans and have them work with you to develop a rubric (see sample rubric on the following page).



Sample Rubric for Culminating Activity



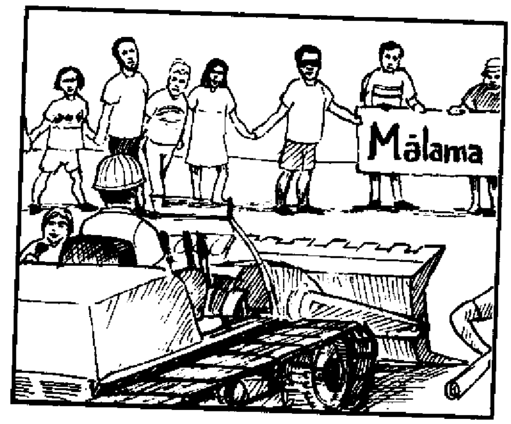
Performance Indicators	Kūlia Exceeds Standard	Mākaukau Meets Standard	‘Ano Mākaukau (Almost at Standard)	Mākaukau ‘Ole (Below Standard)
Social Studies: Citizenship / Participation Create a plan of action related to the solution (identify the stakeholders involved and the steps to take). ***Points*____**	Action plan clearly identifies the problem, who is affected by it, and the value systems that are important. Plan shows appropriate process, critical thinking, and innovative solution.	Action plan clearly identifies the problem, who is affected by it, and the value systems that are important. Plan shows appropriate process and evidence of critical thinking.	Action plan is limited; needs more development to show how solution will be reached.	Action plan is unclear; shows inappropriate process or solution.
Include some evidence of implementation of the plan (letter writing campaign, circulating petition, testifying to appropriate decision makers) ***Points*____**	Evidence shows that action plan was carried out and includes students' reactions to the plan with suggestions for follow-up in the future.	Evidence shows that action plan was carried out.	Evidence shows that some of the steps in the action plan were completed.	No evidence of completing the action plan is provided.
Group Work (Laulima – Cooperation) ***Points*____**	Participates fully in group task; shares appropriately; listens attentively; and encourages others	Participates fully in group task; shares appropriately and listens attentively	Demonstrates effort but needs work on listening attentively and/or cooperating	Lacks effort and cooperation; shows poor listening skills

I NOTICED:

De-bait Goes On!

- What are your beliefs and values regarding the conservation of fishponds in Hawai'i?
- How do we participate responsibly in civic actions?

Hawai'i DOE Content Standard



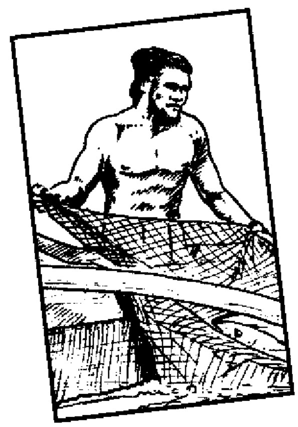
Social Studies: Citizenship/Participation

- Students understand roles, rights (personal, economic, political) and responsibilities of American citizens and exercise them in civic action.

Grades 6 – 8 Performance Indicators

- Explain the roles and responsibilities (social, political, economic) of citizens and the importance of participation for the benefit of society.
- Select a concern that requires positive action for a designated group/community.

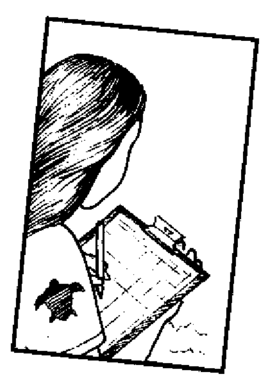
Key Concepts



- Issues related to the conservation of fishponds involve different perspectives depending on the values and beliefs of the people involved.
- People in a community have a responsibility to identify and evaluate solutions to issues, such as fishpond conservation, based on recognition of their own and others' values and beliefs.

Activity at a Glance

Groups of students analyze different perspectives as they assume the roles of citizens in a mock town meeting to debate the issues surrounding the future of the community's fishpond.



Time

3 - 4 class periods

Skills

oral communication, critical thinking, evaluating sources of information, identifying and clarifying personal values

Assessment

Students write a summary that:
- explains the roles and responsibilities of citizens involved in the debate;
- describes the importance of participation in civic actions for the benefit of society; and
- clarifies their own personal values related to the issue of fishpond conservation.

Vocabulary

intrinsic – belonging to the real nature of a thing; inherent or natural
subjective – not objective; personal
ecological – living organisms and their relationship to the environment
derived – to get or receive something from a source; received
values – the beliefs or standards of a group of people

Materials

Provided:
- student reading
- student activity sheet
- role cards
- teacher key

Needed:
- paper
- color markers
- costumes (optional)

Advance Preparation

Make copies of the student reading and student data sheet for each student. Make one set of the role cards, cut, fold and place in a container.

Teaching Suggestions

Note: The fishpond controversy in the student reading is based on a hypothetical newspaper article; the positions of government, groups and individuals are fictional.

Part 1

1. Generate a discussion with the class to define "value system." *(A value system is a set of standards or beliefs determined by a specific group of people.)* Review the different types of value systems. See box on following page and write these on the board.

2. Distribute a copy of the student reading to each student. Have students take turns reading it aloud in class.

3. Divide the class into groups and give each a student activity sheet. Ask students to complete the sheet analyzing the value system of each group or individual (fisher, scientist, kūpuna, developer, business people, and student group) and list their reactions to the proposed development.

Value Systems

Aesthetic	focus on appreciation of intrinsic (natural) and subjective (not objective; personal) qualities, such as beauty of an area
Cultural	related to maintenance of practices and attitudes of a culture
Ecological	concerned with living things and the function of ecological (living organisms and their relationship to the environment) systems
Economic	related to the exchange of goods and services
Educational	concerned with benefits derived (received) from learning
Legal	concerned with the law and its enforcement or application
Recreational	related to the use of leisure time

Adapted from: Ramsey, J.M., Hungerford, H.R. and T. Volk, "A Technique for Analyzing Environmental Issues," *The Journal of Environmental Education*. Vol. 21 No. 1, Fall, 1989.

4. Discuss students' responses and review each group or individual's position, beliefs and values. *(Refer to the teacher key for the answers and note that students may discover answers not listed on the teacher key.)*

   Discussion Questions

   - What are some of the issues groups face in considering whether or not to restore a fishpond?
   - Which of the beliefs are based on fact and which are based on opinion?
   - Which beliefs are based on economic values? Which are based on cultural values? Do some groups have more than one value system?
   - Is it important to restore fishponds? Why or why not?
   - What are some solutions?

Part 2

5. Divide the class into small groups of no more than three to four students per group. Pass around the container of role cards and have one member from each group draw a card.

6. Ask each group to read the role card and discuss as a group the following question: Does your group's role support the restoration of the fishpond? Why or why not?

7. Distribute the student data sheet to each group and have students complete it and identify the value system expressed on their role cards.

8. Tell students that they will be presenting the position described on their role cards at a mock town meeting to be held in class. Set a date for the meeting and review students' responsibilities. To prepare for the meeting, they will need to review the student reading and glean information that will support their position.

9. Each group may also wish to prepare a poster or diagram to use in their presentation detailing the impact fishpond restoration may or may not have on their community.

10. Stage a town meeting in the classroom with each group presenting its position. You may suggest students dress their part to heighten the dramatic quality of the experience. Give each group a time limit for presenting and allow time for other groups to respond.

11. Have each student write a summary of the debate, addressing the points identified in the assessment activity.

Portions of this activity were adapted from: *The 'Ōhi'a Project*, Grades 7-8, "Case Studies." Bishop Museum and Moanalua Gardens Foundation.

Adaptations/Extensions

- Have students identify a fishpond in their school community and study an issue or problem connected to the pond. Ask students to recommend a solution and implement a civic action (for example pond clean-up, planting of native plants, removing alien species, or rebuilding pond walls). See the Appendices for a list of resource people on each island that may assist in the organization of a service project at your local fishpond.

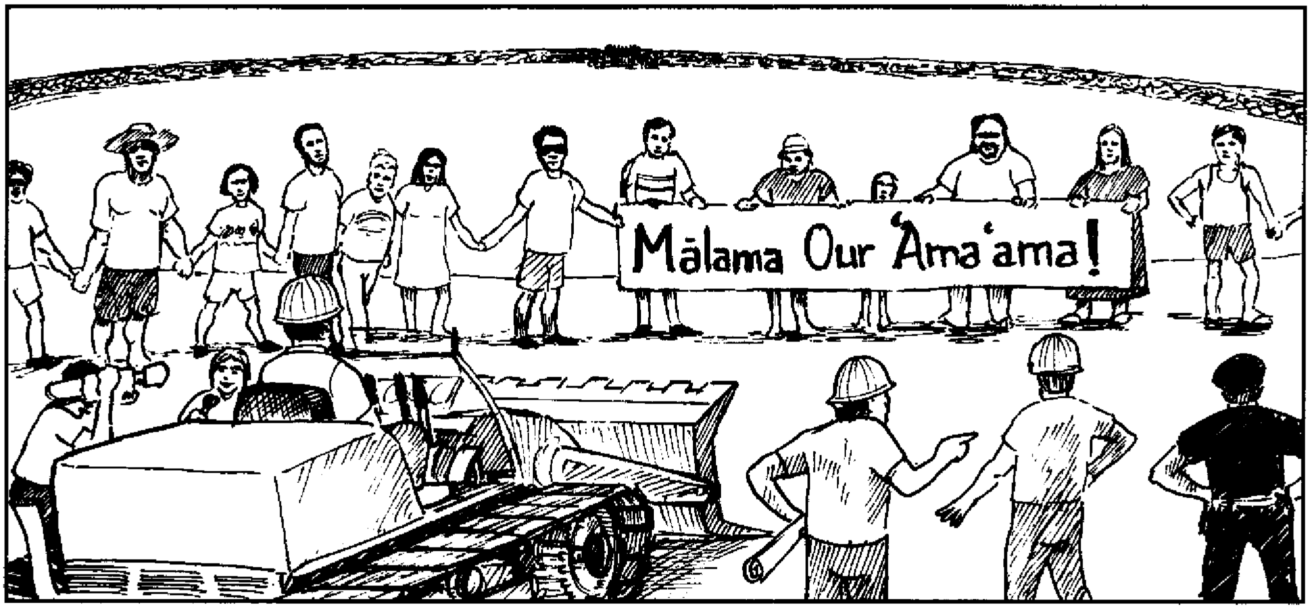
- Invite individuals or members from a group who are connected to a fishpond to come and speak to the class. Have students ask questions and categorize each speaker's response according to the value system and beliefs.

- Have students produce a mock television newscast from the student reading or role cards. If your school has access to video equipment, videotape the newscast and share it with your school community.

- Stage a mock trial – fishpond owners versus developers or scientists versus developers.

School Group Blocks Fill-in of Kūpono Fishpond

By Frances Fisch
Leemoo Wire Service



KŪʻĒ, Hawaiʻi – A dozen or so students from Mālama Middle School and their families and friends blocked bulldozers today from destroying Kūpono – their community's fishpond.

The group formed a human chain similar to early Hawaiians who would transport stones from the mountains to the sea to build their aliʻi's fishpond rock walls.

As they linked arms chanting, "Mālama our ʻamaʻama!" equipment operators sat stunned in silence idly waiting for further orders from their superiors.

"I've never seen anything like this before," said Hardhat McKenzie – the supervisor on duty at the construction site. "These folks mean business!"

Mālama students and their supporters decided to become involved when plans were announced to fill in their community's 117-acre fishpond to pave the way for 100 affordable new homes.

Moonee May, President of the Coalition of SOS or Save Our (open) Spaces, voiced her concern.

"My group regularly visits Kūpono. This is a perfect place for us to become re-energized, rejuvenated and to restore a sense of spiritual well-being. The beauty, tranquility and serenity make it an ideal place to re-connect with oneself."

But land developer, Bill D. Lott, reminded his opponents that the project has widespread community support.

"It's not as if we haven't done our homework," said land developer, Bill D. Lott. "We've been very open about our

School Group Blocks Fill-in of Kūpono Fishpond (continued)

intentions (the housing project) and have involved the community every step of the way."

Two years ago, Lott pulled together community leaders to have a "talk story" session about the project.

Through monthly discussions, leaders from both sides identified Kūpono as the area that would be the least affected by the project.

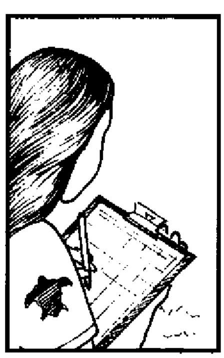
"The water, electrical and sewer lines are ready to go," said community leader, Meg A. Monopolee. "If Mr. Lott tried to build elsewhere the infrastructure would not be in place. He would end up tearing up a larger area of what we want to preserve."

Other community leaders agreed citing the urgent need to build affordable housing.

"We need homes built and now!" said community leader and Executive Director Helen H. Omeless of Wee Care – a shelter for homeless families. "I can understand the historical significance of these rock-wall fishponds. But we've got babies living on the streets, using cardboard boxes for a crib. It seems that some of us are somewhat confused about our priorities."

But Mālama Middle School students had some reservations.

"I know we need homes," said Mālama sixth grader, Ah Mah Ama. "But we use this pond as our living classroom to study its ecosystem. This is home to so many creatures, and someone's decided to kick them out!"



Lott, claims the group is being impractical.

"They're misinformed," Lott said. "Families here in Kū'ē are suffering because there are no affordable homes for them. I drive by a dozen or so homeless families everyday who really need a house to live in. The majority of the community supports this development." Lott also mentioned that part of the plan is to include a three-acre park with baseball and soccer fields.

"This is a win-win situation for everyone," Lott said.

According to community leader and project supervisor, Hardhat McKenzie, Kūpono fishpond would be the best place in the area to build homes.

"The other areas being considered would require Mr. Lott to condemn property owners' land so that he could build roads to access the new development," McKenzie said. "Sounds to me that Mr. Lott has the community's best interest at heart."

Mālama students, relatives and friends learned of the project just days before bulldozers converged on Kūpono fishpond.

"It's not like we had all year to plan and organize," said Mitch Mākāhā, organizer of the group. "My son came to me upset about what was going to happen to the fishpond, and I

School Group Blocks Fill-in of Kūpono Fishpond (continued)

decided that if it meant this much to him, then we needed to do something about it."

In ancient Hawai'i loko kuapā (shoreline fishponds) were used exclusively by ali'i.

The combination of the rock walls and the mākāhā (sluice grate) made the loko kuapā unique to Hawai'i.

"You will never find anything like these ponds in the world," said Dr. Klive Kamaru – expert in fishpond archaeology at the University of Owyhee.

"Considering that this structure is over 400 years old and relatively intact, our government should be considering ways to restore this pond, not destroy it."

Kamaru and his colleagues are a few of the professors at the university who bring their students to the pond to participate in regular field studies.

But state attorney, Luke E.L. Swere, pointed out that for Kamaru to continue his visits to Kūpono, the state would need to make vast improvements on the fishpond, which they can ill afford.

"The amount of money it would cost taxpayers to make the necessary improvements to the pond would be phenomenal. The state is at risk by allowing groups to visit the fishpond in the first place. Potentially, the state could be held liable for anyone who is injured on the property while currently under our jurisdiction. This is a class action suit waiting to happen," E.L. Swere said.

When loko kuapā were built, it took thousands of people living within the ahupua'a to move 25-pound boulders from the uplands to the ocean.

The amount of time it took to construct and maintain the fishpond was lengthy.

One senior family member of the Mālama group recalls his 'ohana's connection to the fishpond.

"My ancestor was ali'i to this ahupua'a," Kupuna Aka Mai said. "There are chants in our family's genealogy that describe this fishpond, the kinds of fish that were raised here and the plants that were grown in this area and used for medicines. This is where my kūpuna lived and now these people want to destroy it!"

But businessman, Entre Penure supports the idea of progress claiming the development will attract more homebuyers to this part of the island and stimulate the economy.

Penure who owns several wedding chapels – two directly built on fishpond walls – says it's time for the community to look toward the future.

"This is an exciting opportunity for this community to generate income,"

School Group Blocks Fill-in of Kūpono Fishpond (continued)

Penure said. "Businesses will be established as a result of more homes being built. People will have jobs. I predict that in a few years this community will be the next Waikīkī!"

Another resident who supports the idea of bringing more tourists to Kū'ē is Sam Shrood, owner of Fishpond Fun – an eco-tourism business that provides recreational activities for tourists at Momi fishpond.

"We have about five to six hundred visitors everyday," Shrood said. "They love this place. It gives them a real feel for what Hawai'i was like back then."

Shrood provides tourists with cultural experiences at Momi fishpond from pole fishing to crab catching to sharing stories about the area where early Hawaiians thrived.

Shrood is also known for his floating restaurant on the fishpond where island residents flock to dine on seafood cuisine.

"If these homes are built, it will be just the beginning of better things to come," Shrood said. "By developing this area, we can anticipate more visitors to this side of the island, which will generate more jobs for our community."

But K.B. Cruz, a local fisher, says the development will destroy fishing grounds that he and his family have fished for generations.

"This is my 'āina," Cruz said. "My father, my father's father, and my father's father's father have fished here for years. If these homes are a go, then we gotta go."

Cruz claims that as a result of the new housing development, untreated sewage will be dumped into the ocean killing fish and other marine life that co-exist.

"These bananas don't know what they're doing!" Cruz said. "Instead of filling in they should try and figure out a way to make the fishpond productive. So many people here in Kū'ē have to buy food from the big supermarket chain. What this government should be doing is to give Kūpono back to the people so they can grow fish and limu."

Gov. Benny N. DeJets assured both sides that he will carefully consider all positions before making a final decision.

"The bottom line is we can't make it affordable if we have to build elsewhere," Lott said. "Kūpono is the ideal location."

De-bait Goes On!

Teacher Key

People Involved	Position	Belief (s)	Belief (s) based on (check one) fact	opinion	Value System
Moonee May	Opposes	• Filling the fishpond will prevent her group from enjoying its aesthetic appeal and their spiritual enlightenment.			Aesthetic
K.B. Cruz Kupuna Aka Mai	Opposes	• Cultural practices will be lost. • Ancestral ties are important.			Cultural
Ah Mah Ama Dr. Klive Kamaru Students from Mālama Middle School	Opposes	• Educational research and field activities to study marine and plant organisms will cease.			Ecological
Sam Shrood Hardhat McKenzie Entre Penure Bill D. Lott Helen H. Omeless	Supports	• Development will provide more jobs, increase revenues, and stimulate the economy. • Homes for the needy and low-income housing for people will be built.			Economic
K.B. Cruz	Opposes	• The fishpond could be used to raise fish to be sold at area markets.			Economic
Dr. Klive Kamaru Mitch Mākāhā Ah Mah Ama Students from Mālama	Opposes	• Educational activities at the fishpond will cease.			Educational
Luke E.L. Swere	Supports	• Liability issues are a concern.			Legal
K.B. Cruz	Supports	• Enjoys the benefits of leisure fishing.			Recreational

De-bait Goes On!

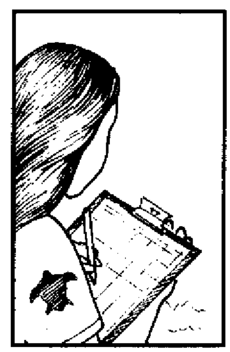
Student Activity Sheet

People Involved	Position	Belief (s)	Belief (s) based on (check one) fact	opinion	Value System

Role Cards

Moses Moi, Inc.
A conglomerate of fishers who are dedicated to restoring the fishpond. Their goal is to re-stock the pond and raise fish and limu (seaweed) to be sold in local stores. They would like their community to become self-sustaining by growing more food locally.

Cy N. Tists, Ltd.
A group of scientists supporting restoration efforts of the fishpond. This group currently uses the fishpond for scientific observation. Primarily they use it to observe fish in their natural habitat and study how the fish respond to currents, tides and the changes in seasons. They would like the pond to be used as a site for college students to gain practical experience.



H.U.L.A. Who Lah Grp.
A group of cultural practitioners who want to see the fishpond fully restored. They support restoration and have committed to eliminating invasive species and re-planting with native plants. Their goal is to offer educational and community group workshops at the fishpond that would focus on moʻolelo (stories), native vegetation in the surrounding area and its significance to Native Hawaiians. They donate their time to mālama (care for) the pond.

Role Cards

D.E. Veloper, Corp.
A wealthy group of land developers have submitted a proposal to the city to construct 100 affordable new homes on the fishpond site. The homes would offer low-income families an opportunity to buy a home. They have already agreed to donate part of their profits to the neighborhood intermediate school. The proposed development will provide jobs to unemployed construction workers in the community.

Baitum, Unlimited
A group of fishpond owners who support restoration for the purpose of eco-tourism. These owners have created a thriving business, which allows tourists to take boat rides across the fishpond. Visitors may also fish for their dinner and if they need access to a restroom, convenient "floating toilets" are available for emergencies. For a significant discount, they will allow local families to visit.

Wed N. Bells, Inc.
A group of wedding chapel owners who support the idea of building wedding chapels on fishpond walls. They are in negotiations with several fishpond owners to erect quaint chapels on their pond walls. A large part of their profits will go towards developing a parking area in an empty lot next to the fishpond, which will provide parking for guests. They help the local economy by attracting tourists to the area and providing local jobs.

6

Mālama Loko I'a

- How have human activities affected the environment of the loko i'a?
- In what ways can students become involved in caring for fishponds today?

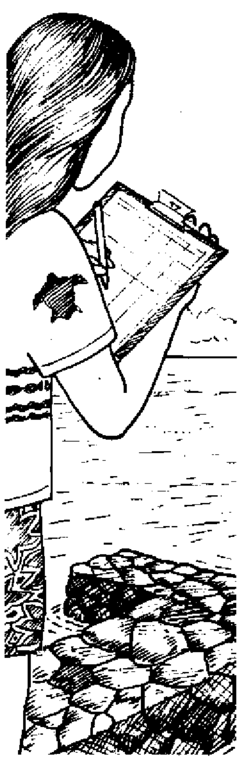
Hawai'i DOE Content Standard

Social Studies: Citizenship/Participation

- Students understand roles, rights (personal, economic, political) and responsibilities of American citizens and exercise them in civic action.

Grades 6 - 8 Performance Indicators

- Select a concern that requires positive action for a designated group/community.
- Create a plan of action related to the solution (identify the stakeholders involved and the steps to take). (culminating activity)
- Include some evidence of implementation of the plan (letter writing campaign, circulating petition, testifying to appropriate decision makers). (culminating activity)



Key Concepts

• Hawaiian fishponds are affected by a number of human activities including those that cause soil erosion, stream alteration, water pollution, and the introduction of alien species.
• Activities to mālama (care for) fishponds may include helping to restore physical features of the ponds, preventing pollution of streams and coastal waters, helping to remove alien species, planting native plants, and educating others about the value of fishponds.
• Fishponds in Hawai'i are valuable cultural resources that are being restored and managed for food production, educational enrichment and to reconnect people to the life of the land.

Activity at a Glance

Students investigate a fishpond to learn more about the physical and natural resources and how the pond has been affected by human activities. Students follow up with a culminating activity that demonstrates caring for the loko i'a.

Prerequisites

De-bait Goes On! and at least one activity from each of the prior units

Skills

observing, reasoning, collecting data, writing

Assessment

Students:
- Write a summary of the ways that human activities have affected the environment of the fishpond.
- Work in small groups to propose a project that they will carry out to demonstrate mālama (caring for) the pond.

Vocabulary

mālama – care for
native – being the place or environment in which a person was born or a thing came into being
alien – not having originated in or not occurring naturally in a particular region or environment
introduce – to bring in or establish, as something foreign or alien
biodegradable – capable of decaying through the action of living organisms
moʻolelo – story, legend, history, tradition
dissolved oxygen – molecules of atmospheric oxygen near the water surface that become mixed in and stay dissolved among the water molecules, expressed in milligrams per liter (mg/l) or parts per million (ppm)
salinity – the total amount of dissolved salts in water, expressed as grams of salts per kilogram of water (g/kg) or as parts per thousand (ppt)

Time

1 class period and a day at the fishpond

Materials

Provided:
- student data sheets

Needed:
- clipboards (one per group)
- pencils
- rubber bands to secure papers to clipboard

Advance Preparation

- Make four sets of the student data sheets.
- Schedule a field site visit to the fishpond. Contact the curriculum coordinator or a person on your island (see Appendices) to make arrangements for your visit. The coordinator will help with scheduling a date for your class to visit the fishpond, lining up resource people to be available the day your class visits the fishpond, providing you with a list of supplies you may need and assisting you with any other inquiries.
- Send home field trip permission slips along with a note to parents about what students will need.

Before Visiting the Fishpond

1. Tell students that the class will be visiting a fishpond to learn more about the ahupua'a, the life in the pond, how the pond works, and ways that human activities affect the pond today. Explain that there will be resource people on site to help them explore at four different learning stations. Review the stations and the key concepts that will be covered.

   - Ahupua'a: In what ways have human activities in the ahupua'a affected the fishpond?

   - Life in the Pond: What lives in the fishpond and how do organisms respond to different conditions, including human changes to the environment?

   - Loko I'a: How does the fishpond work? How have human activities affected the working of the pond today?

   - Plants/Mo'olelo: Which plants are native to the area? What are the effects of the alien species on the site? What do mo'olelo (legends) reveal about Hawaiian culture?

2. Divide the class into four groups. Distribute the student data sheets and review them with the class. Explain that each group will be responsible for collecting information that will help students develop an action plan to help care for the pond.

3. Have students decide how they will share the responsibility of recording information at each of the learning stations at the pond.

4. Discuss safety precautions and appropriate clothing and footwear for the field excursion. Explain that students will not be going into the water but that they will be walking on the fishpond walls. Remind them to be aware of the significance of the site they are visiting and to treat it with respect.

Investigations at the Pond

- At the fishpond, each group will participate in four learning stations and will rotate approximately every half hour. Answers to the plant data sheet are provided on the following page.

- Remind students to record information at each station.

After Visiting the Fishpond

5. Ask groups to report on their findings at the pond and have students complete the written assessment activity.

6. Discuss students' summaries of the ways that human activities have affected the environment of the fishpond. Distribute the student activity sheet on value systems and discuss it with students.

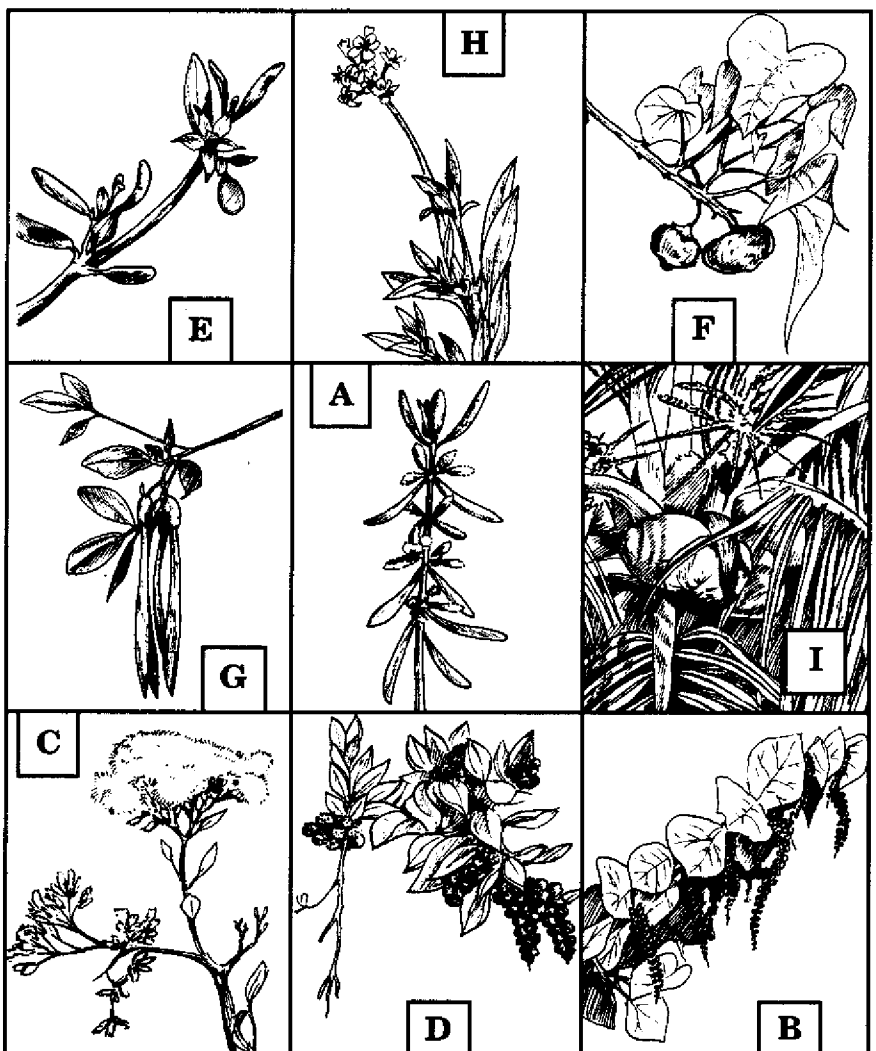
7. Have students work in their groups to propose a project that would address one of the human impacts at the pond. Introduce the culminating activity (see the Unit at a Glance) and challenge students to develop and carry out an action plan to mālama the pond.

Adaptations/Extensions

- Based on their findings at the pond, have each group plan and design a model of the fishpond they visited and what it could look like 10 years from now. Ask students to incorporate a specific value system into their design. Will their future fishpond be used for educational, economical or recreational purposes? Remind students that their design should incorporate a stewardship component.

- Have students adopt a fishpond. Contact the curriculum coordinator on your island to learn about the fishpond nearest you.

Answers: Plant Data Sheet

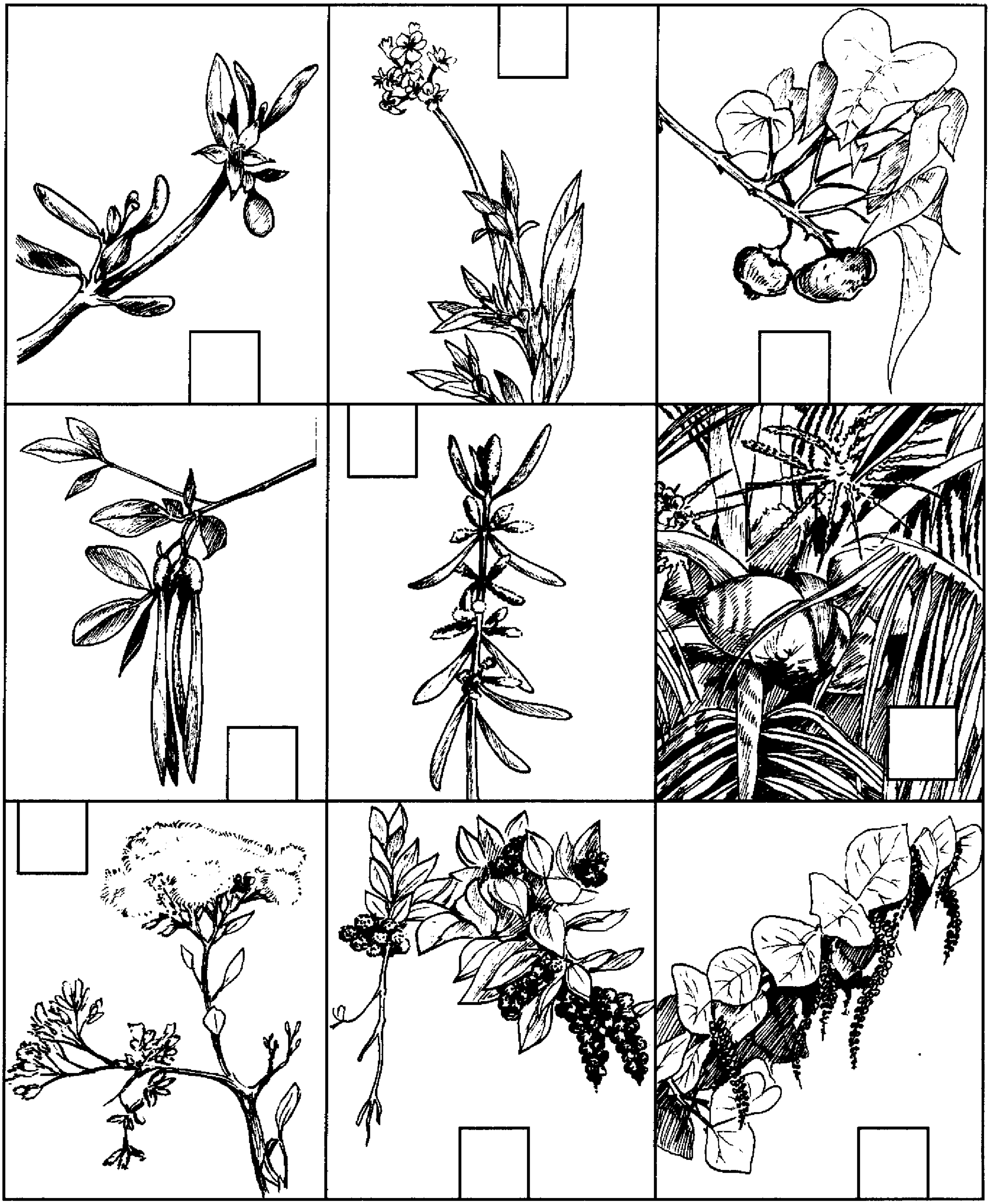


A. ʻĀkulikuli Kai
B. Waina Kahakai
C. Indian Pluchea
D. Silver Buttonwood
E. ʻĀkulikuli
F. Milo
G. Mangrove
H. Hinahina
I. Niu

Plant Data Sheet

Team Name ______________________________

Use these pictures and the plant descriptions provided on a separate sheet to find and identify plants growing around the fishpond. Write the letter from the description under the picture that matches it.



Plant Data Sheet (continued)

Draw a diagram of the wall in this area of the pond. On the diagram, mark the general location where you found each type of plant.

Which type of plant is most abundant?

Which is least abundant?

What effects do you think alien plants have on this area? What plant-related actions do you suggest to mālama this pond?

Plant Descriptions

A. ʻĀkulikuli Kai (alien)
(*Batis Maritima L.*)

The pickleweed is a small woody plant with fleshy leaves. It is edible and can be used in salads. Pickleweed is known to have medicinal value. In the Caribbean, it is used to make soaps and glass products.

B. Waina Kahakai (alien)
(*Coccoloba uvifera*)

The sea grape is known as the "autograph" tree because marks on new leaves produce white lines. The fruit is made into jelly and alcoholic drinks. The root is used medicinally to cure dysentery. The bark is used as medicine to soothe soar throats.

C. Indian Pluchea (alien)
(*Pluchea indica*)

This plant was recently introduced to Hawaiʻi. It is a native of southern Asia. Indian pluchea can be found near coastal areas; look for the pink or purple flowers clustered at the branch ends.

D. Silver Buttonwood (alien)
(*Conocarpus erecta sericeus*)

This plant grows in or near salt or brackish water and is tolerant of full sun, sandy or alkaline soils. The velvety leaves have silver hairs. The red-brown cone-like fruits are <u>not</u> edible. The wood is excellent for making charcoal and for smoking fish and meat.

E. ʻĀkulikuli (indigenous)
(*Sesuvium portulacastrum*)

This plant grows along the ground, trailing its branches and fleshy stems. It bears a purple flower. The fleshy parts are edible and can be eaten raw or cooked as greens.

F. Milo (Polynesian introduced)
(*Thespesia populnea*)

Milo seeds provide a laxative, and the young leaves can be cooked or eaten raw. The dry globular fruits are not eaten at all. The yellowish flowers will wilt as the day progresses, shriveling and turning to a purple or pink color.

G. Mangrove (alien)
(*Rhizophora mangle*)

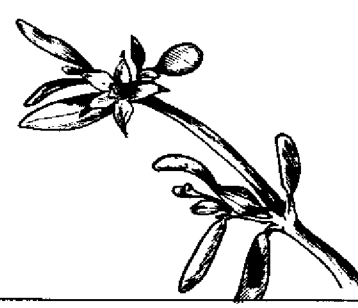
Mangrove was introduced to the Islands in 1902. Their aerial roots trap sediments, which hold together and extend the land area. However, these plants are choking traditional Hawaiian fishponds. The bark and shoots can be used to produce dye.

H. Hinahina (indigenous)
(*Heliotropium anomalum* var. *argenteaum*)

The hinahina has gray or silver leaves and white flowers, which are sometimes used in lei making. If the kōkoʻolau (beggar ticks) plant was not available, early Hawaiians would brew the leaves of the hinahina to produce a tonic tea.

I. Niu (Polynesian introduced)
(*Cocos nucifera*)

The coconut palm sometimes reaches heights of 100 feet. It has many uses; the coconut fruit is used as a food source and the fronds are used to make baskets. In old Hawaiʻi, women were forbidden to eat the milk and meat of the niu.



Pond Life Data Sheet

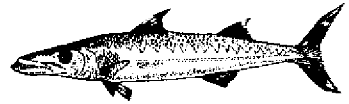
Team Name________________

Date ____________ Time ____________

Pond Data: Salinity ________ (ppt or g/kg) Dissolved Oxygen________ (ppm or mg/L)
Temperature

Find	Identify it	Think about...
the most abundant "producer" in the pond		How is this producer affected by human activities?
an herbivore that feeds on that producer		How is this herbivore affected by changes in water conditions?
an alien plant or animal in the pond		In what ways does this alien species affect the fishpond? What is your evidence?
evidence of a plant or animal response to changes in dissolved oxygen		What causes changes in the level of dissolved oxygen in the fishpond?
evidence of mālama (caring for) this fishpond		What else could you do to mālama the fishpond?

The Ahupua'a Data Sheet



Team Name ____________________

Date ______________ Time ______________

Find	Think about ...
a landform that is included in Hawaiian mo'olelo (legend)	What does the mo'olelo reveal about Hawaiian culture and values? Is the landform connected to the fishpond in any way? Explain.
an example of mālama for this environment	What other ways can people care for the environment of this ahupua'a?
a negative human impact on this environment	How do our actions on land affect water quality in the fishpond?
something that is non-biodegradable (will not break down naturally in the environment)	How might this material affect the fishpond environment?
something beautiful	Describe something beautiful to you in this ahupua'a.

On the reverse side of this sheet, draw a diagram of the ahupua'a where the fishpond is located. Include:

- the boundaries of the ahupua'a
- the major physical features such as streams, ridges or wetlands
- the loko i'a
- a landform that relates to a Hawaiian mo'olelo

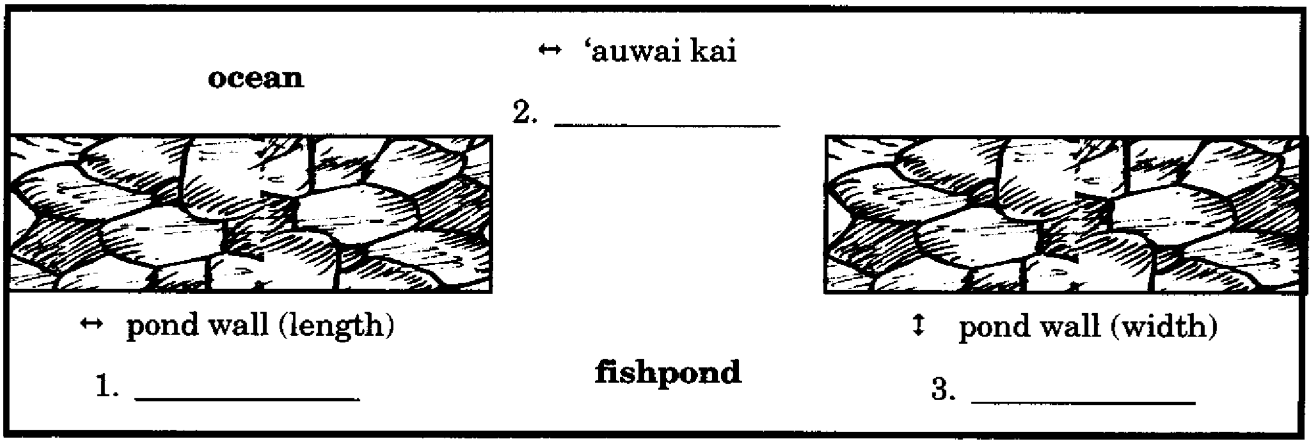
Loko I'a Data Sheet

Team Name ______________________

Date ________ Time ________ Tide Notes ______________________

Type of pond: ____

Does this pond have mākāhā? ______________________________________



A. Use the Walking Wheel and measure:
   1: Length of wall
   2: Width of 'auwai kai
   3: Width of wall

Record your measurements on the numbered lines above.

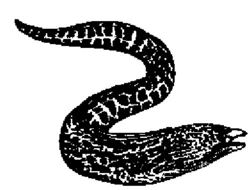
B. Draw an arrow in the diagram above to indicate the direction the tide is flowing through the 'auwai kai.

C. Measure:
   - the speed that a float travels from one end of the 'auwai kai to the other:

     _________ft. per second

   - the water depth in the 'auwai kai:

     _________ft.



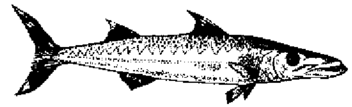
D. Calculate the flow rate:

Depth (ft.) x Width of 'auwai kai (ft.) x Flow (ft. per sec.) x 60/7.5 = GPM (gal. per min.)

____________ x ____________ x ____________ x 60/7.5 = ____________

E. What is the function of the mākāhā and the 'auwai kai?

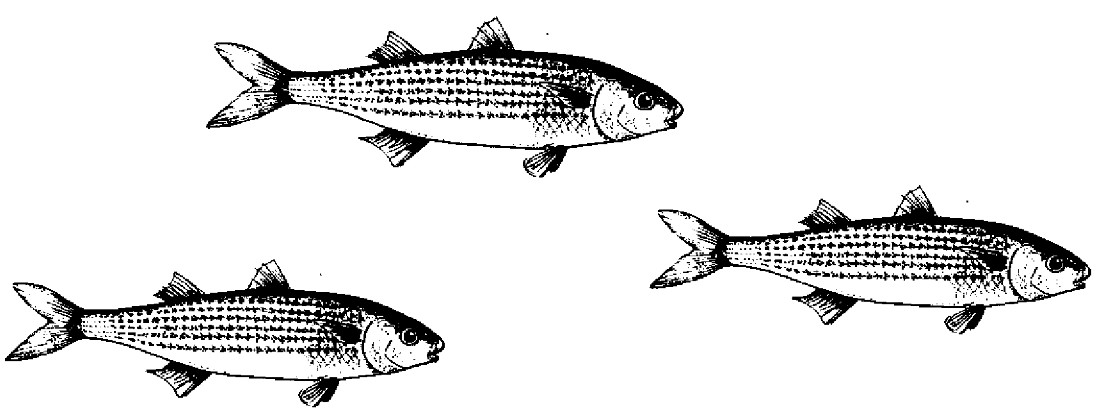
Student Activity Sheet



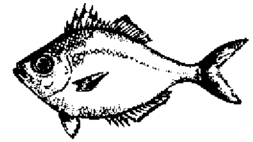
Name ______________________

Make an X in the column that BEST describes the value system that is the focus of each learning station at the fishpond. Describe which of these value systems are important to the action plan that you propose for the fishpond.

Value System	The Ahupuaʻa	Life in the Pond	Loko Iʻa	Plants / Moʻolelo
Aesthetic – pertaining to the appreciation of intrinsic and subjective qualities, such as beauty of an area				
Cultural - related to maintenance of practices and attitudes of a culture				
Ecological – concerned with living things and the function of ecological systems				
Economic – related to the exchange of goods and services				
Educational – concerned with benefits derived from learning				
Legal – concerned with the law and its enforcement or application				
Recreational – related to the use of leisure time				



Unit 4 at a Glance



Grades 9 - 12

Content Standards and Benchmarks	Focus Questions and Activities	Key Concepts	Assessment
Science: Doing Scientific Inquiry Develop and clarify questions and hypotheses that guide scientific investigations. Design and conduct scientific investigations to test hypotheses.	**4E**. What will measures of species' density and diversity reveal about the fishpond ecosystem? **Activity: *Discovering Density and Diversity***	• Determining the diversity (variety) and density (number of individuals per unit area) provides information about the structure of an ecosystem and the relative abundance of native versus introduced organisms.	Students: • Develop hypotheses about the density and diversity of species they might find at the fishpond and describe what these measures will reveal about the ecosystem. • Summarize their plans to test hypotheses, including the procedures, materials and equipment to be used.
Science: Mālama I ka ʻĀina Conservation of Resources Analyze, evaluate and propose possible solutions in sustaining life on Earth, considering the limited resources and fragile environmental conditions.	**4F**. How are human activities affecting water quality and the fishpond environment? **Activity: *Mālama Ola: Caring for Life***	• Excessive fertilizers and soil that wash into ponds have a negative affect on water quality and pond life. • Introduced species often compete with native species and have a negative impact on both aquatic and terrestrial environments.	Students: • Write a summary of data collected at the fishpond, including analysis of water quality tests and reports on density and diversity of plant and animal species found. • Describe the consequences of human changes to the fishpond ecosystem and propose solutions to mālama the fishpond.

Culminating Activity

Students develop presentations to share their data and conclusions from the fishpond field study with an outside audience. Students' presentations should include:

- visual aids to communicate their hypotheses, methods, and conclusions;
- graphs to display the data collected;
- alternative explanations, conclusions, or models if their hypotheses were not correct;
- analysis of the consequences of change on the fishpond ecosystem; and
- proposals for solutions to negative consequences.

Challenge students to provide reasonable explanations to inquiries/questions from the audience based on sound scientific methods and concepts.

Review criteria for assessing students' presentations and have them work with you to develop a rubric (see sample rubric provided).

Sample Rubric for Culminating Activity

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)
Science: Doing Scientific Inquiry Share the explanation and conclusion with peers or outside audience. Identify and explain the merits and/or demerits of alternative explanations, conclusions, and models. ***Points*** _____	Presentation provides clear explanation of data, methods, and conclusions; provides an exceptional analysis of alternative explanations or conclusions.	Presentation provides clear explanation of data, methods, and conclusions; provides a good analysis of alternative explanations or conclusions.	Presentation lacks focus; some information is clearly presented, but needs more organization.	Presentation is unclear; needs more organization and information to convey data collected and conclusions drawn.
Science: Malama I ka ʻĀina Analyze the consequences of change on the entire system and propose solutions to negative consequences. ***Points*** _____	Presentation clearly analyzes consequences of human changes to the system. Solutions proposed to the negative consequences show evidence of critical analysis.	Presentation clearly analyzes consequences of human changes to the system and proposes thoughtful solutions to the negative consequences.	Presentation analyzes consequences of human changes to the system, but does not propose adequate solutions.	Presentation does not show consequences of human changes to the system or propose solutions.
Visual Aids ***Points*** _____	Visual aids enhance understanding of content; have high visual appeal.	Visual aids support content and are appropriate in quality.	Visual aids are minimal and not entirely effective.	Visual aids are incomplete or not appropriate.

I NOTICED:

Discovering Density and Diversity

6

- What will measures of species' density and diversity reveal about the fishpond ecosystem?

Hawai'i DOE Content Standard

Science: Doing Scientific Inquiry
- Students demonstrate the skills necessary to engage in scientific inquiry.

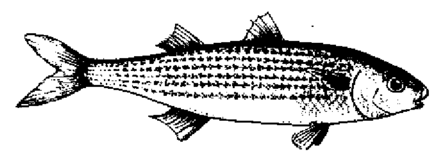
Grades 9 - 12 Performance Indicators

- Ask clarifying questions and develop hypotheses that drive the investigations.
- Describe and carry out a plan to test the hypotheses. Include procedures, materials and equipment needed.

Key Concept

Determining the diversity (variety) and density (number of individuals per unit area) provides information about the structure of an ecosystem and the relative abundance of native versus introduced organisms.

Prerequisite

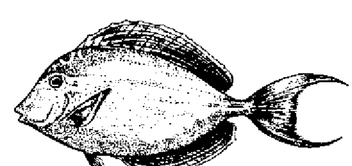


Investigating Interrelationships, Unit 2

Activity at a Glance

Students practice sampling methods that they will use in a fishpond field study and develop hypotheses about the density of limu species they will find at the pond.

Skills



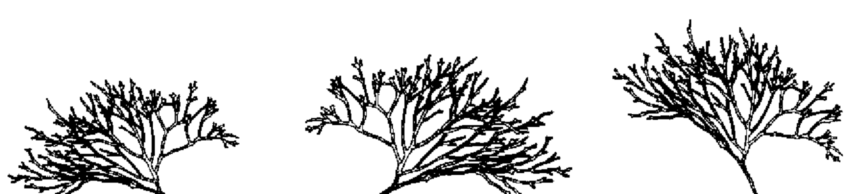
observing, measuring, analyzing, predicting

Assessment

Students:
- Develop hypotheses about the density and diversity of species they might find at the fishpond and describe what these measures will reveal about the ecosystem.
- Summarize their plans to test hypotheses, including the procedures, materials and equipment to be used.

Time

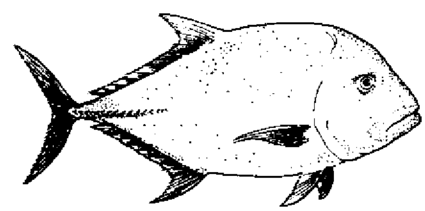
1 - 2 class periods



Vocabulary

transect – a line across a given area, along which information is collected
quadrat – a sampling plot for use in studying plant or animal life
pa'ipa'i – to strike, as in striking the water surface to scare fish into a net
density – the number of individuals per unit area
diversity – variety
relative abundance – the proportion of objects in a group, expressed as a percentage of a particular type
scientific method – a process to generate new knowledge that involves asking a question, stating a hypothesis, planning and conducting an investigation to test the hypothesis, gathering data, analyzing data, communicating findings, and defending or revising conclusions based on evidence

Materials



Provided:

- student activity sheet
- pond life cards (in Appendices)

Needed:

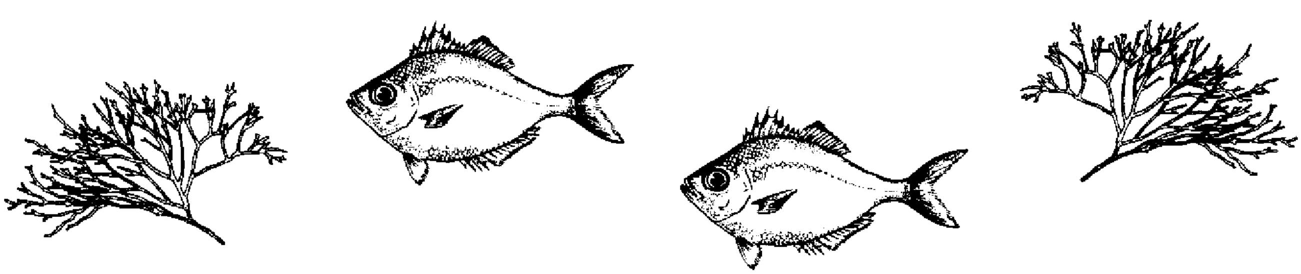
- rope (cut into two 10-meter lengths)
- permanent marker
- 8 meters of 1-inch diameter plastic pipe cut into eight one-meter lengths*
- 8 1-inch diameter plastic pipe "elbow" joints
- box of different colored toothpicks

**These materials are for constructing square meter quadrats to be used in a field study. An alternative is to use a different method of study that requires only two meter sticks.*

Advance Preparation

Copy an activity sheet for each student and copy and laminate the pond life cards provided in the Appendices.

Note: You may want to have students help with the preparation of equipment for the field study. To prepare the two transects, cut the rope into two 10-meter lengths. Mark the ropes with a permanent marker at one-meter intervals. Prepare two quadrats to use with the transects. Cut a 1-inch diameter plastic pipe into eight one-meter lengths. Attach a 1-inch diameter pipe elbow to each length of pipe to make two one-meter squares. Drill a few holes in the pipes of one quadrat so that it will sink (and not float away) when used in the shallow water on the field trip. Note, if making the quadrats is problematic, use the meter stick method instead. (See Background.)



Background

To monitor the diversity of species in the environment and the density of individual species, researchers have devised various ways to estimate plant and animal populations. Taking a total count of species is only possible with large or conspicuous organisms or with those that aggregate into colonies in a relatively small study area. Since taking a total count is not usually feasible, researchers use various methods to estimate the populations of species in a study area. The number transects used and plots or areas sampled is determined by the size of the area to be sampled.

Quadrat sampling – counting organisms in plots along transects of appropriate size and number to get an estimate of density in the area sampled. This method is described in this activity with suggestions for students to practice sampling before going to the fishpond.

Line transect with meter stick – counting organisms that are visible in the spaces between the edges of a meter stick, along transect lines. The researcher holds a meter stick while walking along the transect line and counting species that are seen in the space between the edges of the stick. The number of meters sampled along each transect line depends on the size of the area being studied.

Line transect with threshing rake – (for sampling in an aquatic environment) counting organisms collected with a long handled threshing rake. A two-meter circle is visualized and three rake grabs are made within each third of the circle. The rake is lowered to the sediment, twisted 180 degrees and lifted out of the water. All plants on the rake head are counted and identified to species. Transects are placed perpendicular to the shoreline at regular intervals (depending on the size of the pond). They begin and end at either the shore or an emergent plant bed. Sites are sampled at intervals along each transect.

Teaching Suggestions

1. Explain that students will be visiting a fishpond ecosystem to find out more about the organisms that live in a pond and how human activities are affecting water quality and pond life. Review what students learned in the prerequisite activity, *Investigating Interrelationships* in Unit 2.

2. Discuss methods for studying or sampling animals at the pond. How could students find out the relative abundance (the percentage of total numbers) of a species at the fishpond? Define "density" – the number of individuals in an area. How could they learn about the density of species and diversity or variety of fish at the fishpond?

   - pa'ipa'i method – to catch fish and other organisms in the pond with large surround nets that have weights on the bottom and floats on the top. Pond coordinators will secure the nets and students will form a chain, an arm's length apart, and move like a huge broom across the pond toward the net. They will pa'ipa'i (strike) the water surface with fronds or hands and scare the fish into the net. The animals caught will be a sample of the diversity of species in the pond. The fish will be placed in buckets for students to identify and study.

3. Ask students what some of the shortcomings of this method might be for studying the fish populations in the pond. (*The smaller fish will fit through the holes in the net and some species of fish are more wary of nets and elusive, so this method will provide only a rough estimate of the density and diversity of fish in the pond.*)

4. Discuss why scientists make these measurements. Why is it useful to have information about the diversity or density of species in an area? (*The effect of a population in an ecosystem depends not only on what kind of organism is involved but also on how many. For example, one large predator, such as an ulua, in a 100-acre fishpond would have little effect on the ultimate yield of fish, but 1000 ulua per 100 acres would be great cause for concern.*)

5. Ask students how they could find out about the relative abundance of plants at the pond (in the water and along the shore). Since it's too difficult to count all of the plants, how do we sample the plants and estimate density? Discuss methods described in the Background using transects and quadrats or meter sticks.

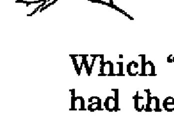
6. Discuss why we might want to study the plant populations in the fishpond. Review the information on the invasive limu pond life cards with students and discuss the problems posed by these invaders. (Refer to the Background in the prerequisite activity, *Investigating Interrelationships*, Unit 2 for additional information.)

7. Have students practice sampling using the quadrat method (or the meter stick) along the transects.

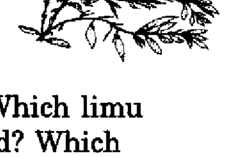
   Procedure

   - Lay the transect lines out in a cleared area (in the classroom or hallway or on the school grounds). Sprinkle various amounts of different colored toothpicks randomly in the area. Each color could represent a different species of limu (algae).
   - Place a quadrat (or a meter stick) next to each transect line at one end of it.
   - Form two groups, one to work on each transect line. Ask students to count and record the number of each colored toothpick they see within each square meter quadrat (or between the edges of each meter stick). Then have them estimate the percent of area covered by each colored toothpick in the quadrat and record that data. It helps to mentally divide the quadrat into quarters, and visually estimate how much space a species is covering.
   - Move the quadrats (or meter sticks) two meters farther along the transects and repeat the sampling procedures with different students counting or estimating cover and recording. Repeat the procedure until everyone has had a chance to participate.

8. For each transect line, ask students to calculate the density for each species of toothpick "limu." The area studied would be the total number of square meters sampled (or meters sampled for the meter stick method).



$$\text{Density} = \frac{\text{\# of individuals}}{\text{area}} \quad \text{or} \quad \frac{\text{total \% covered in quadrats}}{\text{area}}$$



Which "limu" had the highest density (# of individuals per square meter)? Which limu had the highest density when the percentage of area covered was estimated? Which method was more accurate? Which method would be most practical in the field? (*Since it is difficult to count individual species of limu or plant species along the shore, students will probably want to estimate the percentage of cover for each species they record in a quadrat.*)

9. Distribute the student activity sheet and challenge students to develop hypotheses about the diversity of limu species they will find at the fishpond. Use the pond life cards as a resource and encourage students to research additional information (see Resources listed at the end of this activity). Ask students to select one native and one introduced limu species and develop hypotheses about the density of each species in the pond.

10. Ask students to describe a plan to test their hypotheses. Their plans should include procedures, materials and equipment needed. Have them include a description of what these measures will reveal about the ecosystem.

Extensions/Adaptations

- Have students practice the quadrat sampling method, estimating percentage of cover for plants on the school grounds. Another way to practice estimating percentage of cover is to estimate the area of sky that is not covered by clouds.

- Ask students to select one of the species described in the pond life cards and conduct research to learn more about the role of the species in the fishpond ecosystem.

- Invite a scientist from the botany or zoology department of the local college to visit your class and discuss research methods and describe the skills and education required for a career in these fields.

- Have students make equipment for their fishpond field study. They can create viewing tubes to help them see the bottom of the pond when they are studying limu. Cut the bottom out of a 1/2- or 1-gallon shoyu jug. Insert a thin Plexiglass sheet cut to the size of the bottom opening. Seal it with silicone around the edges. Enlarge the top slightly to allow for easier viewing by cutting part of the jug away. Students could also make plankton nets. For detailed instructions on making a plankton net, see http://www.njmsc.org/Education/List%20Lessons/List%20Lesson-Plankton.htm

Resources

Northwest Center for Research on Women. *Rural Girls in Science - Meeting the Challenge Through a Comprehensive Approach.*(Copyright © University of Washington, Seattle, WA. Funded by the National Science Foundation Project HRD-94500053) <nwcrow@u.washington.edu> http://depts.washington.edu/rural/RURAL/design/portfolio.html (This site offers worksheets on the scientific method.)

Offwell Woodland and Wildlife Trust. <offwell1@aol.com> http://www.offwell.free-online.co.uk/biol_sampl_cont.htm (This site provides information on ecological sampling methods.)

University of Hawaiʻi at Mānoa Botany Department. *Hawaiian Reef Algae.* (Copyright © Gerald D. Carr) <gerry@hawaii.edu> http://www.botany.hawaii.edu/reefalgae/

Wiley, John & Sons, Inc. 1995. *Biology Fundamentals.* <rwingerden@smjuhsd.sbcee.kqw.ca.us> http://webpages.charter.net/kwingerden/erhs/aquarium/processs.htm#OrganizingData. (This site has an excellent description of each step in the scientific method.)

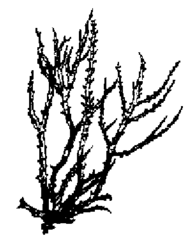
Student Activity Sheet

Name: ______________________________

Clearly state the question that your study is designed to answer and the hypothesis that you have developed.

Research Question

Hypothesis



Method

Describe the method to be used to test your hypothesis. Include the procedure, materials and equipment you will use.

Results

After your field trip, organize and summarize the data that you collected with your team. Use a separate sheet to present this information in graph or table format.

Conclusions

Write a conclusion based on your results. Include answers to the following questions in your conclusion: What is the answer to your research question? Did your results support your hypothesis? If not, what alternative hypothesis might explain your results? Based on your results, what recommendations would you make for caring for the fishpond?

Mālama Ola

To Support Life

Huaka'i (Field Trip) 2

- How are human activities affecting water quality and the fishpond environment?

Hawai'i DOE Content Standards

Science: Doing Scientific Inquiry
- Students demonstrate the skills necessary to engage in scientific inquiry.

Science: Mālama I Ka 'Āina
- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 9 - 12 Performance Indicators

- Use technology and mathematics to collect, organize, and display data appropriately and clearly. Analyze and validate the data.
- Examine the evidence and construct logical and reasonable explanations, conclusions, and models supported by accurate data.
- Analyze the consequences of change on the entire system and propose solutions to negative consequences.

The following indicators apply to the culminating activity. (See Unit at a Glance.)

- Share the explanation and conclusion with peers or outside audience. Provide a reasonable explanation to inquiries/questions from the audience based on sound scientific methods and concepts.
- Identify and explain the merits and/or demerits of alternative explanations, conclusions, and models.
- Revise explanations and conclusions based on additional information.

Key Concepts

- Excessive fertilizers and soil that wash into ponds have a negative affect on water quality and pond life.
- Introduced species often compete with native species and have a negative impact on both aquatic and terrestrial environments.

Prerequisites

Investigating Interrelationships, Unit 2; *Discovering Density and Diversity*

Activity at a Glance

Students gather data about water conditions and plant and animal species in the pond and summarize their findings.

Skills

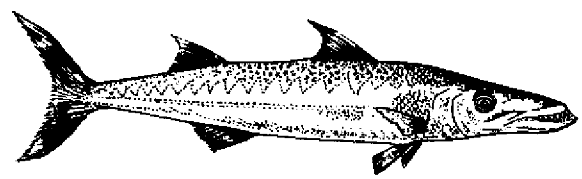
observing, measuring, analyzing, interpreting data

Assessment

Students:
- Write a summary of data collected at the fishpond, including analysis of water quality tests and reports on density and diversity of plant and animal species found.
- Describe the consequences of human changes to the fishpond ecosystem and propose solutions to mālama (care for) the fishpond.

Time

2 class periods and 1-day field trip



Vocabulary

mālama - care for
mālama ola - means of support or livelihood; to support life
water hardness – total amount of dissolved minerals in fresh water measured as mg/L (milligrams per liter) or ppm (parts per million)
dissolved oxygen – molecules of atmospheric oxygen near the water surface that become mixed in and stay dissolved among the water molecules, expressed in milligrams per liter (mg/L) or parts per million (ppm)
salinity - the total amount of dissolved salts in brackish or sea water, expressed as grams of salts per kilogram of water (g/kg) or as parts per thousand (ppt)
algae – limu; aquatic plants and organisms containing chlorophyll
plankton - microscopic animal and plant life floating in bodies of water
phytoplankton - the plant organisms in plankton
pH - a measure of acidity and alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality; lower numbers indicate increasing acidity and higher numbers increasing alkalinity
diatom – unicellular or colonial phytoplankton with a silica based cell wall

Materials

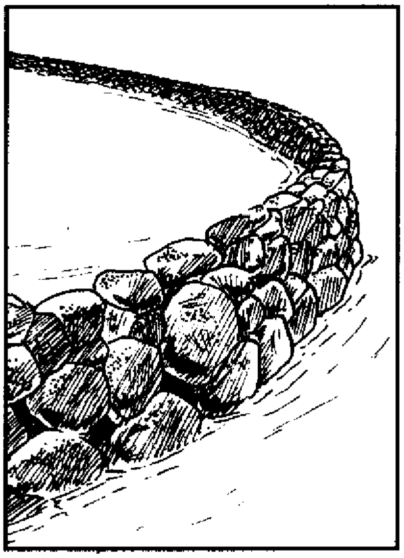
Provided:
- pond life cards (see Appendices)
- coastal plant sheet
- student activity/data sheets
- group sharing - discussion sheets

Needed:

- pencils
- clipboards (one per group or have students use notebooks)
- rubber bands to secure papers to clipboard
- plant identification guides (see Resources)
- small container of rain water (optional)
- water test kits (see Resources)
- viewing tubes (optional, see Adaptations/Extensions in the previous lesson for instructions to make this simple equipment)

Advance Preparation

Copy the student activity sheet for each student. Make four sets of the student data sheets and one copy of the coastal plant sheet and group sharing discussion sheets for use during the field trip. Copy one set of pond life cards. Laminate the pond life cards and the coastal plant sheet.



Check with the school principal about taking students into the shallow water of the fishpond. Students have successfully participated in the pa'ipa'i netting activities and they get a lot more out of the field trip if they are allowed into the pond!

Contact the fishpond manager or field site coordinator (see field sites in Appendices) to schedule a site visit to the fishpond and to determine if equipment, such as nets and water test kits will be available at the sites. If you need to purchase water test kits, see the Resources listed at the end of this activity. Ask the manager or field site coordinator about the use of the data sheets provided with this activity since some sites may have data sheets designed specifically for use on-site.

Background

The shallow depth (two to three feet) of Hawaiian fishponds provides the optimal light conditions for plankton and limu growth. Natural fertilizers such as nitrogen, come from marine animal wastes in the pond. Minerals such as phosphate and calcium, come from incoming streams, and to a lesser degree from the tides, which also contribute salt ($NaCl$, or sodium and chloride). The fishpond mākāhā (sluice grate) and pond walls were designed to allow water circulation from the tides. They allow water to circulate and prevent stagnation and the build-up of sediments, which is critical to maintaining a healthy, balanced fishpond ecosystem.

Natural Fertilizers

Limu and microscopic plankton provide food for the fish grown in the pond—the 'ama'ama (striped mullet) and awa (milkfish). The kia'i loko (fishpond caretaker) guarded and cared for the pond, just as a farmer tends his pastures for cattle. In addition to the nutrients that occur naturally in the pond, the kia'i "fertilized" the pond by adding additional food for fish such as kalo (taro), 'ulu (breadfruit), uala (sweet potato), mussels and stones with limu.

Excessive Nutrients

Excessive nutrients from fertilizers can upset the balance of life in a fishpond by increasing the population of phytoplankton and limu (algae). If too many nutrients are added, algal blooms may form. These blooms can decrease clarity and light penetration, which causes limu to die. As the limu decompose, dissolved oxygen is depleted. Decreased dissolved oxygen then adversely affects the fish population. However, if algal blooms are rich in diatoms they can enhance the natural productivity of the pond. The diatoms in these blooms are nutritious and allow sunlight to warm the lower water layer and enhance natural productivity. According to Carol Wyban, (1992) "Chinese aquaculturists manage their water quality by color. Diatom-rich waters are a golden-brown color."

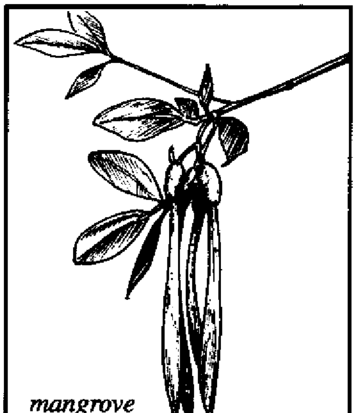
If excessive nutrients increase the phytoplankton concentration to high levels, a potentially lethal situation occurs in the fishpond, especially during the night, when there is no sunlight and no wind or circulation. During the evening the phytoplankton that were making oxygen during the day, stop as the photosynthetic "machinery" shuts down. Because the phytoplankton are also alive and need oxygen to live, they begin to take up oxygen along with the other living organisms in the pond. If there is a large amount of fish, there will be almost no oxygen left in the water. This causes the fish to come to the surface of the water to breathe or gasp for air. Usually, in Hawai'i, we are blessed with the trade winds, but during times of Kona winds, when there is almost no breeze and the water is still, catastrophic overnight fish kills in fishponds have been recorded due to the lack of oxygen in the water.

Siltation

Soil erosion from human activities near the fishpond may also have a negative impact on the fishpond ecosystem. Soil washing into the pond decreases the water clarity, blocking sunlight that the limu needs to grow. When the bottom sediments of soil and decayed organic matter in the fishpond get too thick, the sediment layer needs to be scraped toward the 'auwai kai to be flushed out with the ebbing of the tide. This practice prevents the depletion of dissolved oxygen, which can occur when large amounts of organic matter are left to decay in the pond. When students net fish in the pond with the pa'ipa'i method (see prerequisite lesson, *Investigating Interrelationships*), they help to stir up sediments that are then washed out with the tide.

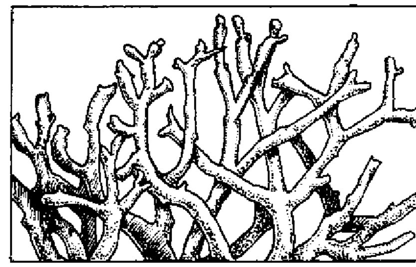
Invasive Species

One of the most visible invasive plants that students may observe at the fishpond is the introduced red or American mangrove (*Rhizophora mangle*). This small tree was introduced to Hawai'i from seeds brought in from Florida in the early 1900s. Mangrove trees were introduced to the Islands to prevent soil erosion. The American Sugar Company planted seedlings on the upper slopes of Moloka'i. However, the mangrove quickly spread to the coastline where it now thrives in brackish water on most of the Islands. The mangrove root system establishes itself within the walls of the fishpond. This causes sediment to be trapped, turning some fishponds into wetlands and mudflats. Mangrove also blocks sunlight, preventing the growth of limu, on which the 'ama'ama (striped mullet) feed.



mangrove

Invasive limu species are also spreading on reefs and in fishponds, displacing native species and altering the structure of these ecosystems. Two of the most common aggressive species are *Gracilaria salicornia* and *Acanthophora spicifera*. See the pond life cards on these species and the information provided in the prerequisite activity, *Investigating Interrelationships*.



Gracilaria salicornia

Some Factors Affecting Fishpond Productivity

Acanthophora spicifera

- *water depth*: ponds two to three feet deep allow sunlight penetration that favors the growth of phytoplankton, zooplankton and limu.

- *water hardness:* minerals are dissolved in the rain water after it touches the ground. Water that is "hard" contains calcium and magnesium compounds. If rain water passes through soft rocks like chalk or limestone, it picks up these minerals. If it passes through hard rocks, such as granite or through peaty soils, it does not pick up these minerals and so remains soft. General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) of calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

- *salinity*: the salinity (amount of salts dissolved in brackish or sea water) fluctuates with tides, depths and proximity to freshwater streams and springs. Apple and Kikuchi (1975) reported a range of salinity in fishponds they studied to be from 2 to 32 ppt (parts per thousand).

- *circulation*: water circulates with the incoming tide to wash sediments out to sea and prevent stagnation and accumulation of bottom sediments. Bottom sediments are composed of silt and a layer of decaying detritus, or muck. These decomposing sediments take dissolved oxygen out of the water and produce hydrogen sulfide. These sediments appear as black mud that smells like rotten eggs. In areas of the pond with this decomposing layer, Apple and Kikuchi (1975) report that a hydrogen sulfide level above 3 ppm (parts per million) is considered injurious to young fish.

- *dissolved oxygen*: Apple and Kikuchi (1975) tested dissolved oxygen levels in 18 Hawaiian fishponds and found a range from 6 to 13 ppm. The mean level of 7.9 ppm indicated high levels of photosynthetic activity in the ponds. Like temperature, the level of dissolved oxygen will vary throughout the day with changes in temperature, light and cloud cover.

- *turbidity* (water clarity): the clarity of the water is related to the presence of mineral or organic particles suspended in water. Clear water allows sunlight to penetrate and the cooler water at the bottom to warm up. Cloudy water as a result of high turbidity reduces this sunlight and may reduce the growth rate of the limu, phytoplankton and fish.

- *pH:* the pH, (degree of alkalinity or acidity) of the water is measured on a scale of 1 to 14, with 1 being most acidic, and 14 being most alkaline. Due to the presence of minerals in Hawaiian waters, the pH of brackish water fishponds is generally alkaline (8.0 – 9.0).

- *water temperature:* the temperature varies seasonally and throughout the day. In a healthy pond, the temperature is relatively even in the water column and ranges from 64 to 88 degrees Fahrenheit in Hawai'i.

Teaching Suggestions

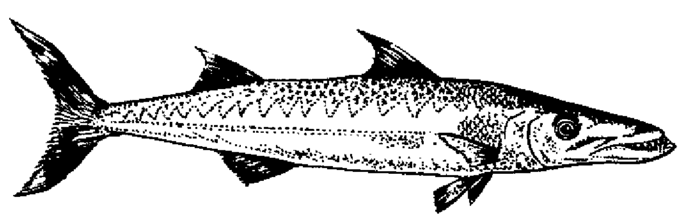
1. Divide the class into four groups and distribute the data sheets that students will use at the fishpond. Review the data sheets and discuss the tasks that students will complete at the pond. If students have not practiced using the transect and quadrat method described in the *Discovering Density and Diversity* activity, review it with them. If students made predictions about organisms they would find at the pond in the Unit 2 prerequisite lesson, review those predictions with the class.

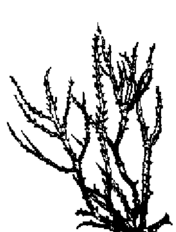
2. Review the water quality tests that students will conduct at the pond. Introduce new vocabulary. If you have water test kits available, have students practice conducting the water hardness test, comparing tap water and rain water. Complete instructions are provided with the kits.

3. Discuss safety precautions and appropriate clothing and footwear for the field trip. Recommend that students wear old clothes that can get dirty, covered shoes or tabi, and sunscreen and/or a hat.

4. Discuss proper protocol for visiting the pond and the need to mālama (care for) the environment and one another. If students know an oli (chant) that would be appropriate to share with the fishpond coordinator or manager upon arrival, review the chant with them. See the *Haku Mele Aloha* activity in Unit 3, Grades 4 – 5, for suggestions on composing simple mele in Hawaiian.

5. Distribute the student activity sheet on mālama and ask students to complete it as homework before visiting the pond.





Investigations at the Pond

- Remind students of the cultural significance of the site they will be visiting and the need to treat it with respect. Students should be reminded that some fishpond walls are very fragile and could shift or settle when stepped upon.

- At the fishpond, students in groups A and B will work at the pond life station and students in groups C and D will work at the plant life station. After about an hour, the groups will switch stations. Group A will switch tasks with group C and group B will switch tasks with group D.

Pond life station – Students collect data on water conditions and living organisms in the loko iʻa. Group A will study water hardness and salinity. Group B will study dissolved oxygen and plankton. Both teams will be conducting tests simultaneously and then share their results with one another. Use the questions and answers provided on the group sharing discussion sheet to summarize.

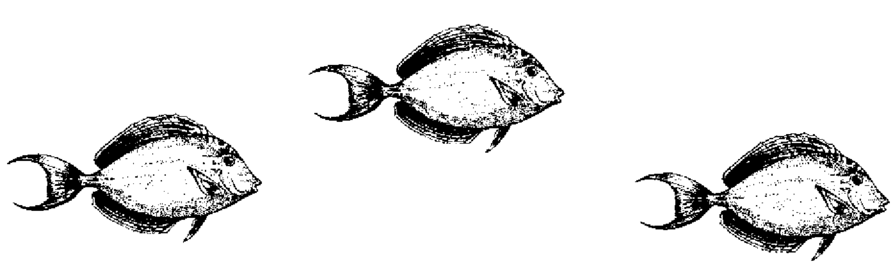
Plant life station – Students will work in two groups. Group C will run a transect in the shallow water of the pond and estimate the percentage of cover for different types of limu. Group D will run a transect in another area to study the plants growing next to the pond. The two groups will then share with each other - demonstrating their methods and what they learned. Use the questions and answers provided on the group sharing discussion sheet to summarize.

- The final session will be with the entire class participating in catching fish in the pond using the paʻipaʻi method to gather fish in a large net. The site coordinators will work with students to teach them this method of catching fish.

After Visiting the Fishpond

6. Ask groups to report on their findings at the pond. If they were unable to identify a species at the pond, have students use their notes and sketches and look it up (see Resources). Ask students to use their data to create graphs illustrating the diversity and density of species found. Encourage them to use the computer to display their data appropriately and clearly.

7. Have students write their conclusions about the fishpond based on their data and complete the assessment activity. Discuss the culminating activity (see Unit at a Glance).



Adaptations/Extensions

- Arrange to collaborate with other schools on the study of water hardness and/or pH in regard to rain water on the Big Island versus rain water on the other islands. Acid rain resulting from the vog will have a different pH. Other simple studies of pH can include a comparison of rain water only, rain water plus kamani tree leaves; tap water only and tap water plus kamani tree leaves. The effect of kamani tree leaves on pH can be compared to the native use of hau tree leaves in the loʻi kalo. Between plantings, Hawaiians mixed hau tree leaves with soil and left the loʻi fallow for a period of time. The leaves added nutrients but also lowered the pH of the soil. This was figured out by trial and error using things in the environment long before modern-day scientific studies.

- Have students conduct simple tests comparing buoyancy in salt water versus tap water using a water hydrometer. If a hyrometer is not available, use some capped, plastic test tubes marked with gradients. Place sand or lead in the tubes to the amount that will allow the tubes to float upright in tap water. Then place the same tubes in salt water, and see which are more buoyant. (The tube will float higher and lean to one side in the salt water.) If sea water is not readily available, add Hawaiian sea salt to tap water (to reach a salinity of 50 ppt). (Note: Salinity hydrometers can be purchased through Aquatic Eco-Systems for about $8.00 plus shipping. If ten are more are purchased, the price drops.)

Resources

Aquatic Eco-Systems, Inc. <aes@aquaticeco.com> http://www.aquaticeco.com/ (Source for throw nets, aquaculture supplies and equipment)

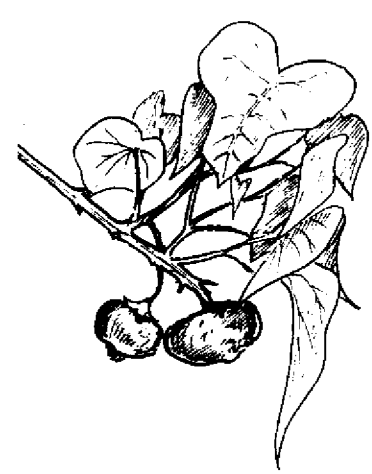
Eldredge, Lucias G. and C.M. Smith. (Editors). 2001. *A Guidebook of Introduced Marine Species in Hawaiʻi*. Bishop Museum Technical Report 21, Bishop Museum Press. Honolulu, HI.

Hach Company. <orders@hach.com> www.hach.com/ P.O. Box 389, Loveland, CO 80539 (800) 227-4224 or (970) 669 3050. (Analytical systems and technical support for water quality testing, with solutions for lab, process, and field)

LaMotte Company. <mkt@lamotte.com> www.lamotte.com/ P.O. Box 329, 802 Washington Avenue, Chestertown, MD 21260 (800) 344-3100. (Products for the analysis of water, soil, and air)

Merlin, Mark David. 1999. *Hawaiian Coastal Plants.* Pacific Guide Books. Honolulu, HI.

University of Hawaiʻi at Mānoa Botany Department. *Hawaiian Reef Algae.* (Copyright © Gerald D. Carr) <gerry@hawaii.edu> http://www.botany.hawaii.edu/reefalgae/ (Click on Marine Plant Research, Hawaiʻi Coaral Reef Initiative for invasive algal species.)



Student Data Sheet - Groups A & C — Pond Life Station

Name ________________________________ Date__________

Water Hardness (minerals in water)

- Use the test kit provided.
- Read safety information and follow instructions in the kit for testing each sample.
- Record the water hardness in ppm (parts per million).

tap water	rain water

What could account for the difference in water hardness of the two samples?

Salinity

- Use the 4 SeaTest Specific Gravity Meters, one for each sample (see Resources) .
- Pour water into the meter. Tap it gently to get the bubbles out.
- Record the salinity in ppt (parts per thousand).

tap water	stream	loko iʻa	ocean

What causes salinity to be different in the samples?

How is hardness related to salinity?

Student Data Sheet - Groups B & D — Pond Life Station

Name ______________________________ Date __________

Dissolved Oxygen

- Set up two containers: one with fresh water, and one with pond water.
- Measure and record the salinity of each water sample.
- Use the dissolved oxygen meter (handle carefully — it's expensive).
- Check to see if the meter has stabilized (around 7 ppm) before using.
- Turn on the bubblers and place one hose in each container.
- Measure and record the dissolved O_2 levels in ppm (parts per million) in both water samples.

stream	loko i'a

What could cause the dissolved oxygen to be different for the samples?

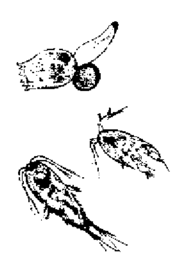
When do you think dissolved O_2 is higher in the pond – day or night? Why?

Add 10 - 15 small fish to the container with pond water. Remove the bubbler. Record the dissolved O_2 levels. What do you observe about the behavior of the fish once the dissolved O_2 level goes below 4 ppm? What types of human activities might cause the dissolved O_2 level to drop in the pond?

Life in the Pond: Plankton

- Place the plankton net in the current found in the 'auwai kai. Wait for 10 minutes.
- Carefully remove the plankton net and pour water from the container at the bottom of the net into a jar.
- Use a pipette to transfer the water into test tubes.
- Look at tubes through magnifiers.
- Count the number of zooplankton in the test tube. Compare your findings with those of the other students.

Types of Plankton	No. of zooplankton in the test tube

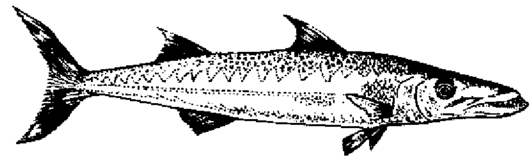


Group Sharing – Discussion Questions

Pond Life Station

(copy 1 sheet for teacher)

Report from Groups A & C:



- What is water hardness?
  (minerals in the water)

- What are the results?
  (Tap water is approximately 150; Rain water is about 50. Results will vary.)

- Why are the samples so different?
  (Tap water contains minerals that have collected in the rain water as it seeps through the ground.)

- Why is salinity different in the samples?
  (Salinity – the amount of mineral salts dissolved in the water – fluctuates with tides, depths and proximity to freshwater streams. Researcher Kikuchi found 2 – 32 ppt for fishponds.)

- How is salinity related to water hardness?
  (The saltiness of the ocean is from dissolved minerals, including runoff from the land.)

Report from Groups B & D:

- Why is dissolved O_2 less in salt water than fresh water?
  (Dissolved minerals in salt water take up space where O_2 would be. Researcher Kikuchi found a range 6 – 13 ppm dissolved O_2 in fishponds.)

- When is dissolved O_2 higher in the pond – day or night?
  (The level of dissolved O_2 varies; it's higher during the afternoon when photosynthesis has been occurring for awhile; lowest at night when photosynthesis stops.)

- What did you observe about fish behavior when dissolved O_2 drops below 4 ppm?
  (The safe zone is above 3 ppm. Below that fish have a hard time breathing and come to the surface for air.)

- What is the role of phytoplankton in the fishpond?
  (primary producer of dissolved O_2 and a source of food)

- How does the amount of phytoplankton in the pond affect the level of dissolved O_2?
  (Phytoplankton increases dissolved O_2. However, an increase in nutrients can cause excessive phytoplankton growth and algal blooms, which decrease clarity and light penetration, causing limu (algae) to die. When excess limu and phytoplankton decompose, dissolved oxygen is depleted. When the phytoplankton concentration is high, and there is no sunlight, wind or circulation, available oxygen gets used up and fish come to the surface to breathe. During times of Kona weather when there is almost no breeze and the water is still, catastrophic overnight fish kills have been recorded due to the lack of oxygen in the water.)

Group Sharing – Discussion Questions (cont.) Pond Life Station

(copy 1 sheet for teacher)

- Why is the shallow depth of a Hawaiian fishpond an ideal place for plankton and limu growth?
  (Sunlight, which is essential for photosynthesis and growth, is able to penetrate to the bottom of the pond.)

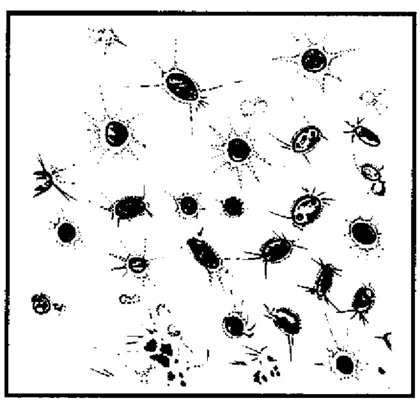
- What are the natural "fertilizers" that keep the plankton and limu growing?
  (wastes from organisms growing in the pond, trace minerals dissolved in fresh water)

All Groups Report

- What kinds of fish were caught in the net using the pa'ipa'i method?
  (Note: the pa'ipa'i method will only catch the larger-size fish. Most of the fish in the pond are small and will be able to escape the net.)

- Which fish were most common? Which were least common? How does this fit with the predictions we made in class about the species of fish we would find?

- How does the pa'ipa'i method we used to catch the fish benefit the pond?
  (The silt that is stirred up by people in the pond is washed out with the ebbing tide. This helps to clean the pond and allows for more dissolved oxygen to be available to the fish.)



phytoplankton

Student Data Sheet: Groups C & A — Plant Life Station

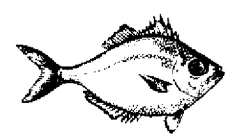
Name ____________________________________ Date__________

Sampling Limu

1. Lay the rope transect out along the pond wall in the area designated. Place the quadrat in the water next to the pond wall at the beginning of the transect.
2. Use the pond life cards to identify and record the limu species that you find within the quadrat. If you are unable to identify a limu species, sketch it and give it a name. (Make a detailed sketch to refer to when you research the type of limu back in class.)
3. Estimate and record the percentage of area that each species covers within the quadrat. Then move two meters along the line, place the quadrat down and record again. Repeat the process until you have sampled at least three areas.

Use the pond life cards to identify limu species. Sketch limu that you cannot identify.
Note: if you have look boxes or viewing tubes available, use these to help you view limu underwater. The sediment that is stirred up when walking in the pond will clear if you stand still for several minutes.

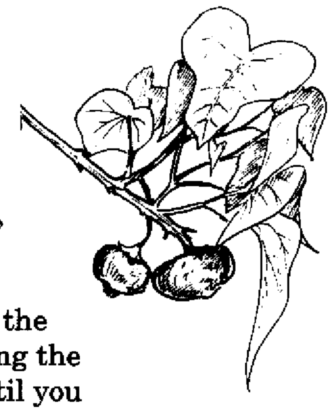
Sample Area	**Plant Species Found Status (E=endemic, Ind.=indigenous, Int.=introduced)**	**Percent Cover (for each species)**



Student Activity Sheet: Groups D & B — Plant Life Station

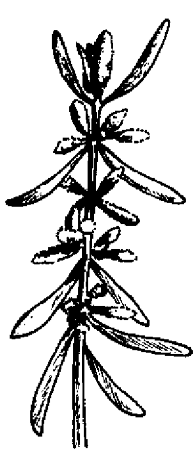
Name ______________________ Date__________

Sampling Plants Growing Around the Pond



1. Lay the rope transect out along the pond wall in the area designated. Place the quadrat at the beginning of the transect. Line one side of the quadrat up with the edge of the rope.
2. Use the coastal plant sheet to identify and record each plant species that you find within the quadrat. If you are unable to identify a plant, sketch it and give it a name. (Make a detailed sketch to refer to when you research the type of plant back in class.)
3. Within the quadrat, count the number of each type of plant, or record the percentage of area that the species covers. Then move two meters along the line, place the quadrat down and record again. Repeat the process until you have sampled at least three areas.

Use the coastal plant sheet to identify plants. Sketch plants that you cannot identify.



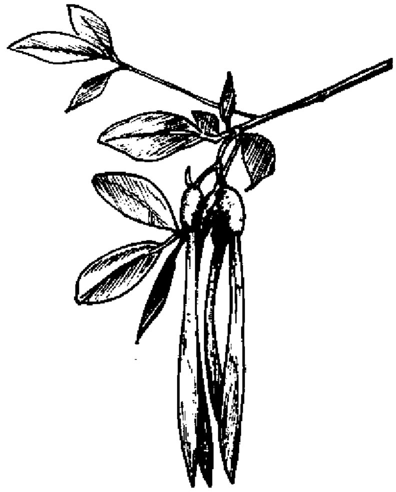
Sample Area	Plant Species Found Status (E=endemic, Ind.=indigenous, Int.=introduced)	Percent Cover (for each species)

Coastal Plant Sheet

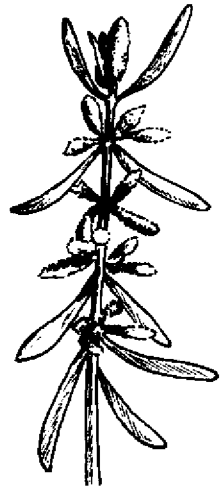
ʻĀkulikuli

Hinahina

Milo

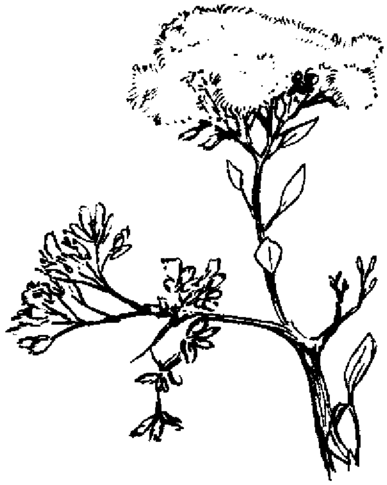


Mangrove



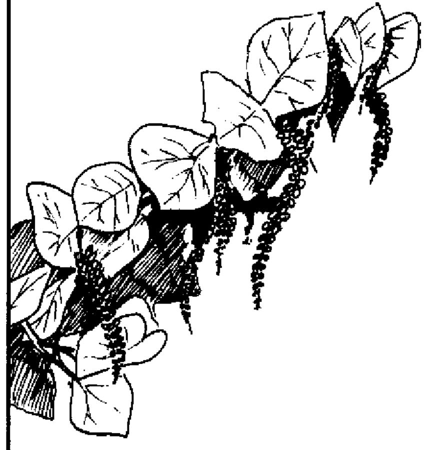
ʻĀkulikuli Kai

Niu



Indian Pluchea

Silver Buttonwood



Waina Kahakai

Coastal Plant Descriptions

1. ʻĀkulikuli (indigenous)
(*Sesuvium portulacastrum*)

This plant grows along the ground, trailing its branches and fleshy stems. It bears a purple flower. The fleshy parts are edible and can be eaten raw or cooked as greens.

2. Hinahina (indigenous)
(*Heliotropium anomalum* var. *argenteaum*)

The hinahina has grayish silvery leaves and white flowers, which are sometimes used in lei making. If the kōkoʻolau (beggar ticks) plant was not available, early Hawaiians would brew the leaves of the hinahina to produce a tonic tea.

3. Milo (Polynesian introduced)
(*Thespesia populnea*)

Milo seeds provide a laxative, and the young leaves can be cooked or eaten raw. The dry globular fruits are not eaten at all. The yellowish flowers will wilt as the day progresses, shriveling and turning to a purplish pink color.

4. Mangrove (alien)
(*Rhizophora mangle*)

Mangrove was introduced to the Islands in 1902. Their aerial roots trap sediments, which hold together and extend the land area. However, these plants are choking traditional Hawaiian fishponds. The bark and shoots can be used to produce dye.

5. ʻĀkulikuli Kai (alien)
(*Batis Maritima L.*)

The pickleweed is a small woody plant with fleshy leaves. It is edible and can be used in salads. Pickleweed is known to have medicinal value. In the Caribbean, it is used to make soaps and glass products.

6. Niu (Polynesian introduced)
(*Cocos nucifera*)

The coconut palm sometimes reaches heights of 100 feet. It has many uses; the coconut fruit is used as a food source and the fronds are used to make baskets. In old Hawaiʻi, women were forbidden to eat the milk and meat of the niu.

7. Indian Pluchea (alien)
(*Pluchea indica*)

This plant was recently introduced to Hawaiʻi. It is a native of southern Asia. Indian pluchea can be found near coastal areas; look for the pink or purple flowers clustered at the branch ends.

8. Silver Buttonwood (alien)
(*Conocarpus erecta sericeus*)

This plant grows in or near salt or brackish water and is tolerant of full sun, sandy or alkaline soils. The velvety leaves have silver hairs. The red-brown cone-like fruits are not edible. The wood is excellent for making charcoal and for smoking fish and meat.

9. Waina Kahakai (alien)
(*Coccoloba uvifera*)

The sea grape is known as the "autograph" tree because marks on new leaves produce white lines. The fruit is made into jelly and alcoholic drinks. The root is used medicinally to cure dysentery. The bark is used as medicine to soothe soar throats.

Group Sharing – Discussion Questions

Plant Life Station

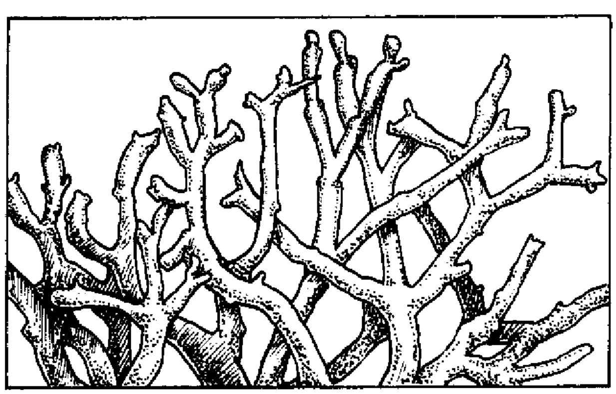
(copy 1 sheet for teacher)

- What species of limu (and plants) did you find?
- Which were most abundant? Which were least abundant?
- Were there any differences between the areas that you sampled? If so, what factors might account for those differences? (For example, in the pond – proximity to currents; on the pond wall – protection from salt spray, shade versus sun, depth of soil)
- How could we use the data collected to estimate the density of plant species in the fishpond and along the shore? Calculate the density for the most common species found.

$$\text{Density} = \frac{\text{\# of individuals}}{\text{area}} \quad \text{or} \quad \frac{\text{total \% covered in quadrats}}{\text{area}}$$

To calculate the density, count the total number of plots sampled and determine the area in square meters. For example, if 3 areas were sampled, the total area is 3 square meters. If 60 individuals were counted the density would be 20 plants per square meter. If students are using percent cover, have them add the total percent cover for each species and divide this by the area – the number of meters sampled.

- Was the species with the highest density native or introduced?
- What impacts are introduced plants having in the fishpond and the surrounding environment? Explain your ideas.
(Introduced or alien plant species that are invasive in a habitat, crowd out native species of plants, which often affects the interrelationships among native plants and animals.)



Student Activity Sheet

Name ______________________________ Date________

Mālama

Mālama means to care for, preserve, protect, tend to, and support.

E mālama i ka ʻāina.	(Care for the land.)
E mālama i nā keiki.	(Take care of the children.)
E mālama i ke Akua.	(Serve the divine.)
E mālama pono ʻoe.	(Take good care of yourself.)
E mālama i kou kino.	(Take care of your body.)
E mālama kekahi i kekahi.	(Watch out for one another.)

In our day and age, we tend to forget this one important concept of mālama (caring). How do we care for each other, especially our families? How do we take care of our ʻāina (land) and our honua (Earth)? Do we mālama those things that are so important to our life—he ola pono (to a good life)? Do we always take, or do we give back with aloha and sincerity? My kūpuna (ancestors) survived in harmony with their environment. I must keep that concept of mālama ʻāina, mālama ke Akua, and mālama i ka ʻohana (family) within my heart and soul, so that I can guarantee my children a good life for their future. I hope you have it in your heart to do the same.

E mālama pono ʻoe! E mālama kekahi i kekahi! Aloha.
Keoni K. Inciong-1997

What does mālama mean in this reading? Have you heard the word mālama used before? Give examples.

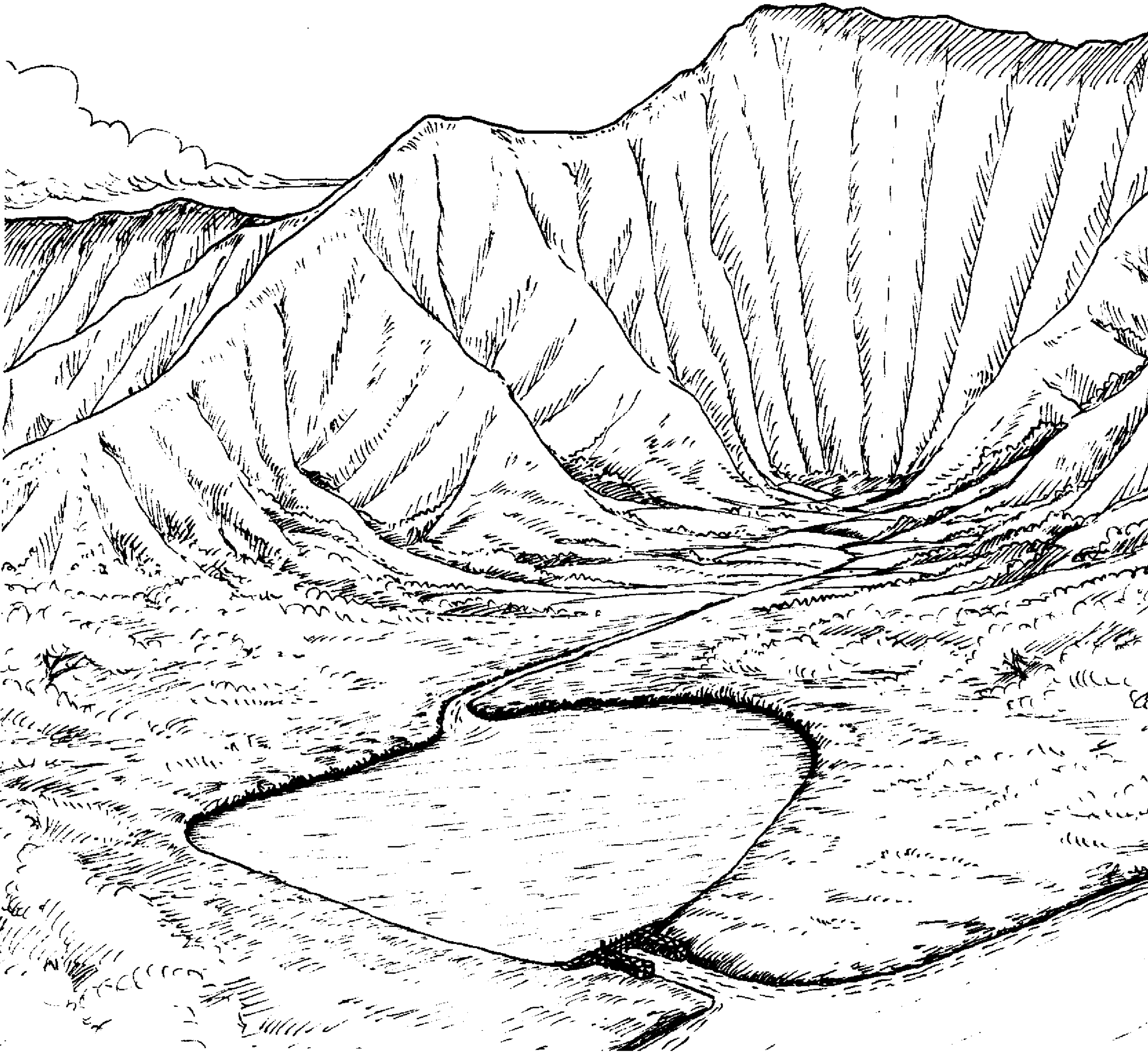
Is mālama a part of your family's life style? Why might it be difficult to maintain that value? Give examples.

How do you express mālama for the ʻāina? Give examples.

Share this reading with a family member or adult friend and record their response to it.

APPENDIX

Glossary



Glossary

(Sources: Pukui and Elbert. 1986. Hawaiian Dictionary;
Webster's Encyclopedic Unabridged Dictionary of the English Language. 1996)

A

acre – a unit of land measure equal to 43,500 square feet or 1/640 of a square mile

ad libitum – at one's leisure

aerate – provide with oxygen

agriculture – raising of plants or animals on land

ʻahaʻaina – feast

āholehole – flagtail fish (*Kuhlia sandvicensis*)

ahupuaʻa – traditional Hawaiian land unit usually extending from mountain summits to the outer edges of reefs

ʻāina – land, environment

akule – big-eyed scad fish (*Selar crumenopthalmus*)

algae – aquatic plants and organisms containing chlorophyll

alien – not having originated in or not occurring naturally in a particular region or environment

aliʻi – chief, ruler

aliʻi ʻai ahupuaʻa – chief who rules an ahupuaʻa land division within a moku

aliʻi nui – high chief

aliʻi moku – chief who rules a moku (land district)

aloha ʻāina – love for the land

ʻamaʻama – striped mullet fish (*Mugil cephalus*)

aquaculture – raising of plants or animals in water

atoll – a roughly circular reef surrounding a broad lagoon

artifact – any object made by humans

assessment – a measurement of a student's ability or skill

ʻaumakua – family or personal gods or ancestors who may take the form of sharks, birds, octopuses, eels, mice, rats, dogs, rocks, caterpillars, clouds, or plants

ʻawa – the kava plant, the root being the source of a narcotic drink

awa – milkfish (*Chanos chanos*)

awa ʻaua or awa ʻawa – ladyfish or tenpounder fish (*Elops hawaiensis*)

ʻauwai – ditch or small canal

ʻauwai kai – ditch or small canal connecting the fishpond to the ocean

axis – a straight line about which a body or a geometric figure rotates or may be supposed to rotate

B

bacteria – various organisms that are involved in fermentation and putrefaction

biodegradable – material that will decompose into the environment; capable of decaying through the action of living organisms

brackish – slightly salty, a mixture of fresh water and sea water

C

caloric energy – energy from food calories

carnivore – animal that eats other animals

catalyst – that which causes activity between two forces without itself being affected

celestial – pertaining to the sky or visible heaven

centimeter – a length measurement of one hundredth of a meter or 0.3937 inches chlorophyll – the green coloring matter of leaves and plants

circulation – the moving or flowing of something from place to place or in a circle

circumtropical – throughout the tropics

conservation – prevention of injury, decay, waste or loss; wise use, management, and preservation of natural resources

consumer – organism that feeds on other organisms

conversion – a physical transformation from one material or state to another

courier – messenger, someone who carries something from one place to another

cultural anthropologist – someone who studies human social and cultural systems, particularly customs, values and beliefs of a culture

D

decimate – to reduce drastically, especially in number

decomposition – the process of organic and inorganic materials being broken down into smaller fragments or simpler compounds

decomposer – organism that feeds on dead plants and animals and helps break them down into nutrients to be used again

density – the number of individuals per unit area

derived – to get or receive something from a source; received

detritus – material that has decayed or rotted

diatoms – unicellular or colonial phytoplankton whose cell walls contain silica

dissolved oxygen – oxygen dissolved in water

diversity – variety

E

ebb – the flowing back of the tide as water returns to the sea

ecological – living organisms and their relationship to the environment

ecosystem – a system formed by the interaction of a community of organisms with their environment

efficiency – ability to accomplish something with a minimal amount of time and energy

ʻeleʻele – long, filamentous, green, edible seaweed

endemic – native to an area; occurring naturally nowhere else

engineer – to arrange, manage, or carry through

environment – all the conditions, circumstances, and influences affecting an area

estuary – the lower part of a stream or river where the currents meets the tide of the ocean

ethnocentric – having race as a central interest; assuming one's group to be superior

eutrophication – the decay of abundant plant or animal life resulting in the lack of oxygen in shallow waters

excavate – to dig or scoop out sand or dirt; to form a hole or depression

F

fathom – a unit of length equal to six feet, usually used to measure depth

feet – length measurements of 12 inches or 30.48 centimeters

fish fry – young fishes

fishpond – an enclosure for keeping fish

fishtrap – a structure for trapping fish

fluctuation – continual change from one position to another flux – change in flow of the of tide

food chain – a series of organisms interrelated in their feeding habits, the smallest being fed upon by a larger one, which in turn is eaten by an even larger one

food web – a series of organisms related by predator-prey activities

fungi – mold, mildew, mushrooms, rusts

G

H

habitat – environment that is natural for the life and growth of an organism

heat energy – added or external energy that causes a rise in temperature, expansion, evaporation, or other physical change

he'e – day octopus (*Octopus cyanea*) or night octopus (*Octopus ornatus*), commonly known as squid

hemisphere – half of a spherical or roughly spherical body (as a planet); the northern or southern half of the earth divided by the equator or the eastern or western half divided by a meridian

herbivore – animal that eats plants

hīhīmanu - stingray

hīnālea – wrasse fish (*Thalassoma* sp.)

ho'ā'o – take a chance

hō'ihi – respect

ho'oilo – cool, wet season in Hawai'i, from October through April

huaka'i – field trip; excursion

hukilau – a seine; to fish with a seine

huli kanaka – profound studies of any kind, moral philosophy, science; anthropologist

hypothesis – assumption or guess

I

i'a - fish or other marine animal

ili – land division, next in importance to an ahupua'a

imu – underground oven

indigenous – native to an area, but also occurring naturally in other areas

ingenuity – cleverness or skillfulness of conception or design

innovation – introduction of new things or methods

intrinsic – belonging to the real nature of a thing; inherent or natural

introduce – to bring in or establish, as something foreign or alien

J

juvenile – young, immature

K

ka hana no'eau – wise deeds

kala – unicorn fish (*Naso unicornis*)

kahāla – amberjack fish (*Seriola dumerilii*)

kai – sea water

kākū – barracuda fish (*Sphyraena barracuda*)

kalo – taro (*Colocasia esculenta*)

ka po'e kahiko – the people of old

kapu – taboo

kau wela – hot, dry season in Hawai'i from May through October

kia'i loko – caretaker of a pond

ko'a – shrine consisting of circular piles of coral or stone, built along the shore or by ponds or streams, used in ceremonies to make fish multiply; or fishing grounds, usually identified by lining up with marks on shore

konohiki – supervisor of an ahupua'a who controlled the land, water, and fishing rights

kuapā – seawall

kula – plains; open country

kuleana – responsibility

Kumulipo – Hawaiian creation chant, source of life

Kūʻula or Kuʻulakai – god of the fishers

Kūʻula stone or Kū stone – any stone god used to attract fish

kuhikuhipuʻuone – expert in the building of fishponds

kūmū – goatfish (*Parupeneus porphyreus*)

L

lā – sun

landform – a natural feature of a land surface such as a mountain, hill, valley, or stream

landmark – a distinguishing landscape feature marking a site or location

landscape – a section of scenery that can be seen from a single viewpoint

larva – early life form that is fundamentally unlike the parent and eventually metamorphoses to become an adult

laulima – cooperation, working together

lawaiʻa – fisher

limu – seaweed

limu kalawai – freshwater pond algae

loʻi – taro patch

lōkahi – balance; unity

loko iʻa – fishpond

loko iʻa kalo – combination freshwater fishpond and taro patch

loko kuapā – seawater fishpond with rock walls situated on a reef flat

loko wai – freshwater or brackish water pond adjacent to a stream

loko ʻume iki – shore fishtrap with lanes to guide fish at both low and high tide

lūʻau – Hawaiian feast

M

macroalgae – large multi-celled plants and organisms containing chlorophyll occurring in fresh or sea water

mahiʻai – farmer

mahina – moon

makaʻāinana – commoners, people that tend the land

makai – toward the sea

mākāhā – sluice grate or gate, as in a fishpond

mālama – care for

mālama ola – means of support or livelihood; to support life

manini – convict tang fish (*Acanthurus sandvicensis*)

mauka – toward the mountain

melatonin – a hormone secreted by the pineal gland that is stimulated by darkness and inhibited by light

mele – song

melomelo – stick or club used as a lure, rubbed or wiped with roasted coconut or kukui nut flesh or aromatic leaves

meter – a length measurement equivalent to 39.37 inches

mile – a measure of length equal to 5,280 feet

microalgae – microscopic photosynthetic (chlorophyll-containing) organisms that are usually single cells; these aquatic forms are often referred to as phytoplankton

moʻala – long-eyed swimming crab (*Podophthalmus vigil*)

moi – Pacific threadfin fish (*Polydactylus sexfilis*)

moku – land district

moʻolelo – story, legend, history, tradition

moʻokaʻao – story, legend, fanciful tale

N

native – being the place or environment in which a person was born or a thing came into being

nehu – anchovy (*Stolephorus purpureus*)

niche – the ecological role of an organism

non-biodegradable – material that will not decompose into the environment nutrient – any matter that, taken into a living organism, serves to sustain it, promote growth, replace loss, and provide energy

nutrient flushing – the washing away of nutrients

O

ogo – seaweed (*Gracilaria* sp.)

ʻōhi'a ʻai – mountain apple tree; type of wood used in the building of mākāhā

ʻōʻio – bonefish (*Albula* sp.)

ʻōlelo noʻeau – Hawaiian proverb

oli – chant

olonā – a native plant that Hawaiians used to make very strong fibers for lashing materials together

omnivore – animal that eats both plants and animals

one – sand

ʻoʻopu – goby

ʻoʻopu hue – puffer fish (*Arothron hispidus*)

ʻoʻopu naniha – goby (*Stenogobius hawaiiensis*)

ʻōpae – shrimp or prawns

organism – any form of animal or plant life

P

pā – a primitive type fishtrap that has a single lane to guide fish at low or high tide, but not at both

pā hī aku – hook used to catch aku (bonito fish)

paʻipaʻi – to strike, as in striking the water surface to scare fish into a net

palani – eye stripe surgeonfish (*Acanthurus dussumieri*)

pāpaʻi – crabs

pāpio – young ulua or jack fish (*Caranx* sp.) less than 10 pounds

performance assessment – a testing method where students are expected to create an answer or product to demonstrate their knowledge and skills

pH – a measure of acidity and alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality; lower numbers indicate increasing acidity and higher numbers increasing alkalinity

photosynthesis – the production of carbohydrates using sunlight energy to combine carbon dioxide and water in the presence of chlorophyll

phytoplankton – the tiny plant organisms in plankton

piko – center

pineal gland – the pineal gland is sometimes called a 'third eye' because of a role in lower vertebrates (such as fish) in sensing light and dark cycles

plankton – floating or drifting organisms in a body of water

pono – in perfect order (as one with nature)

predator – any organism that exists by seizing other organisms for food

producer – plant that makes its own food using energy from the sun

proverb – a wise saying, usually of unknown and ancient origin, that expresses a useful thought; a saying that is in general use and that expresses widely held ideas and beliefs

pū – whistle

puʻu – hill, pile, mound

pua awa – juvenile awa (milkfish)

pua iʻa or pua iʻi – young fish or tiny fry of fish

pualu – yellowfin surgeonfish (*Acanthurus xanthopterus*)

pūhi – eel (*Gymnothorax* sp.)

puʻuone – sand heap or sand dune

Q

quadrat – a sampling plot for use in studying plant or animal life

R

Raiatea – the second largest Island in the French Polynesian Archipelago known as the Society Islands, located directly between Bora Bora and Tahiti

relative abundance – the proportion of objects in a group, expressed as a percentage of a particular type

relief – the difference in elevation between high and low areas in a region

rubric – a working guide for students and teachers, usually handed out or developed with students before the assignment begins in order to get students to think about the criteria on which their work will be evaluated; a guideline for making scoring decisions; a document that clarifies what is expected in a learning experience, and what steps to take to reach higher levels of achievement

S

salinity – the total amount of dissolved salts in water, expressed as grams of salts per kilogram of water (g/kg) or as parts per thousand (ppt)

sandalwood – the fragrant wood of certain trees used for ornamental carving and burned as incense

satellite campus – a facility away from the main campus

scientific method – a process to generate new knowledge that involves asking a question, stating a hypothesis, planning and conducting an investigation to test the hypothesis, gathering data, analyzing data, communicating findings, and defending or revising conclusions based on evidence

sediment – matter that settles to the bottom of a liquid

silt – earthy matter or fine sand carried by moving or running water and deposited as sediment

siltation – to become filled or choked with silt

sluice – an artificial stream or channel for conducting water

spawning – producing or depositing eggs

specimen – a typical animal, plant, mineral or a sample of a substance or material for examination or study

stagnation – to become stale or foul from standing, as a pool of water

subjective – not objective; personal

survey – to look over and examine carefully

sustenance – nourishment, means of sustaining life, means of livelihood

sustainable use – use of a resource in a way that does not compromise the ability of future generations to meet their needs

sustainability – the process of keeping up or keeping going; meeting present needs for resources without compromising the ability of future generations to meet their needs

T

tide – the periodic rise and fall of the waters of the ocean and its inlets

topography – the detailed mapping of the surface features of a place or region

transect – a line across a given area, along which information is collected

trophic – pertaining to nutrition

U

uhu – parrotfish (*Scarus* sp.)

uka – upland, towards the mountains

ulua – jack or trevaly fish (*Caranx* sp.) greater than 10 pounds

'umeke – calabash or gourd

umu – a heap of rocks used to catch small fish

'upena – fishing net

V

values – the beliefs or standards of a group of people

variable – something that changes or alters in form, appearance, character, or substance

W

wai – fresh water

wai kai – brackish or salty water, a mixture of fresh water and sea water

water hardness – total amount of dissolved minerals in fresh water measured as mg/L (milligrams per liter) or ppm (parts per million)

water quality – the characteristics or properties of water

watershed – a region or area drained by a river or stream; drainage area

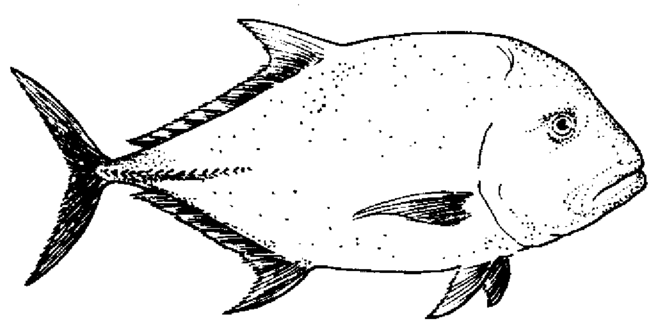
wato – a land management system used in the Marshall Islands of Micronesia

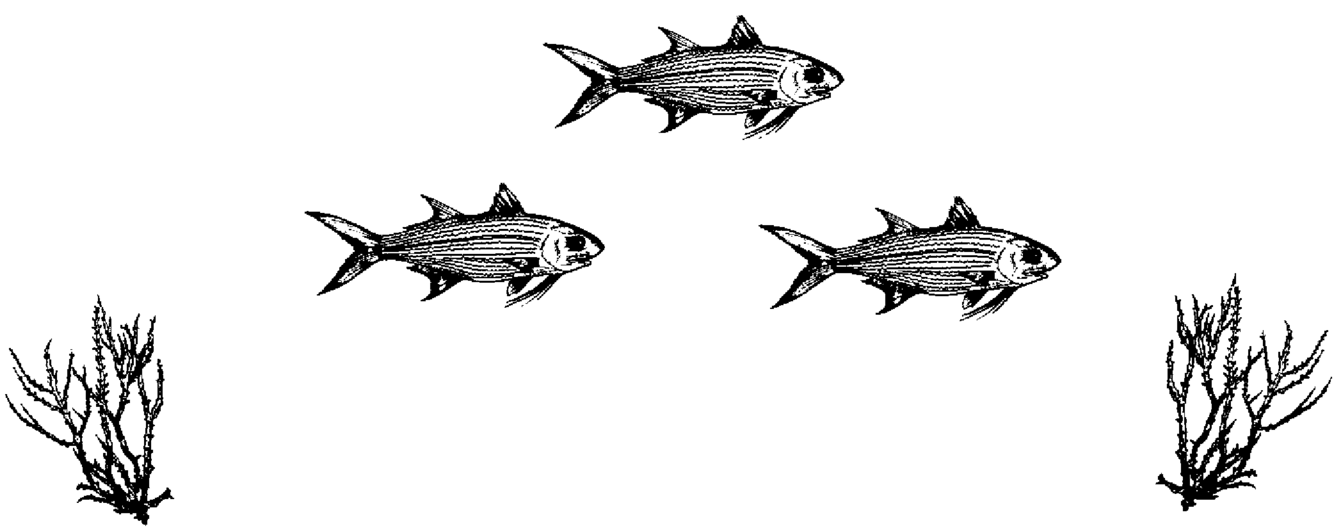
weke – goatfish (*Mulloides* sp.)

XY

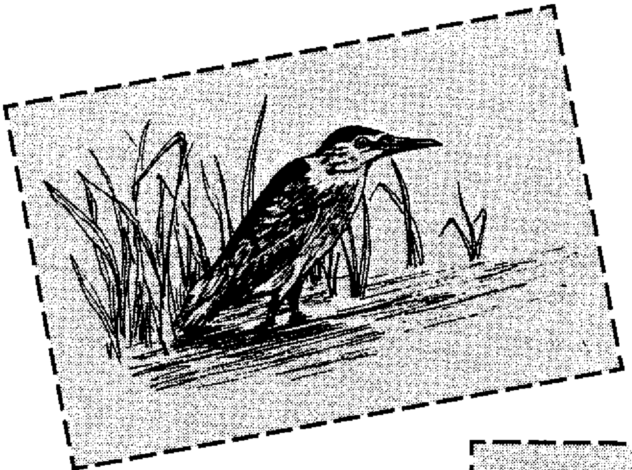
Z

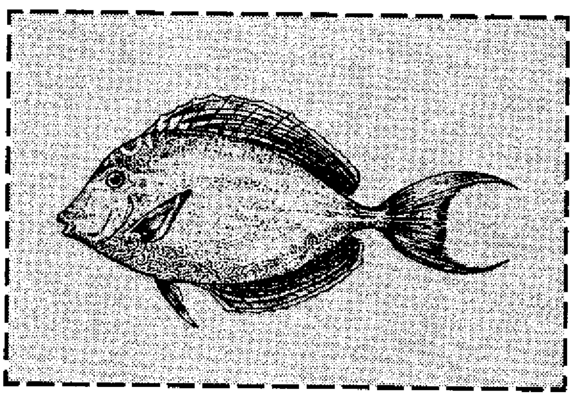
zooplankton – the tiny animal organisms in plankton

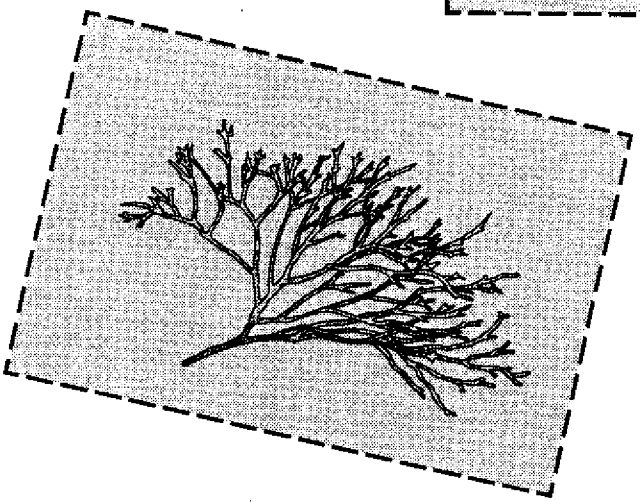


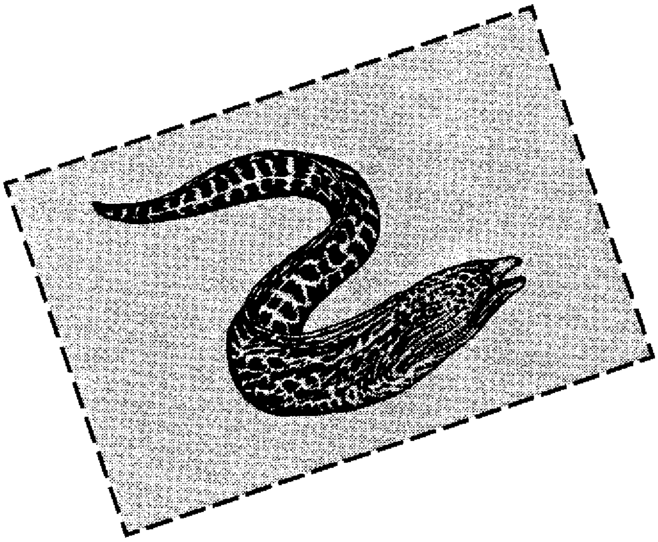


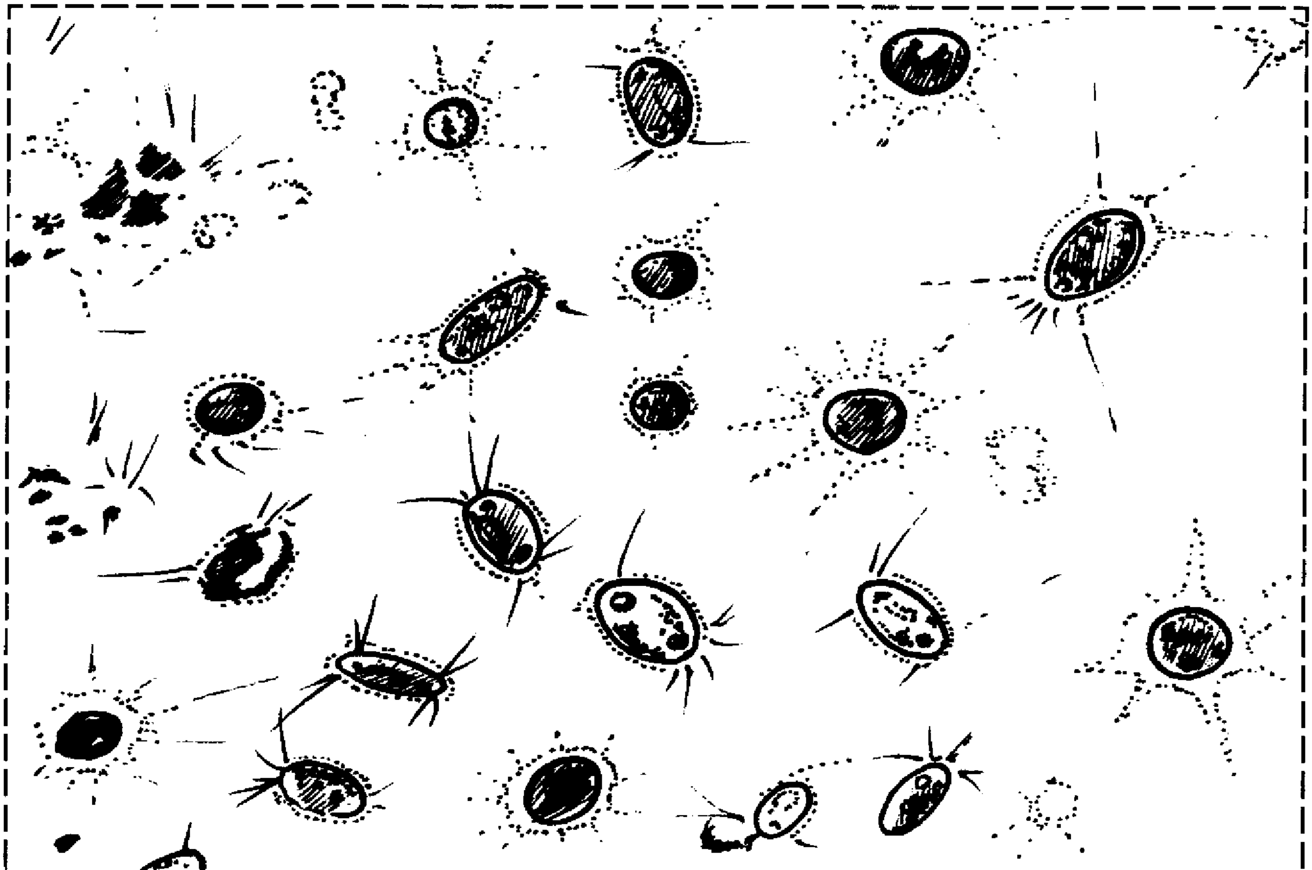
APPENDIX











Producer

Producer

Phytoplankton; microalgae **Indigenous**
(Chlorella sp.) Circumtropical

Eaten by: zooplankton, ʻamaʻama, awa, ʻōpae, clams, oysters

Description: phytoplankton or microalgae are microscopic single-celled aquatic plants that require the aid of a microscope to be seen. Under the microscope, different species appear in unusual and beautiful shapes.

Habitat: Phytoplankton are usually found suspended in the water column. Often times these tiny cells can sink to the bottom of the pond, where some species join to form filamentous chains or strands.

Did you know? Different species of phytoplankton are found in oceans, estuaries, lakes and fishponds. In the oceans they are sometimes referred to as the pastures of the sea. Billions and billions of these cells provide most of the plant material consumed by animals higher in the food web. When these single-celled organisms join or chain themselves together in large numbers, we can see them without a microscope. When the density of phytoplankton is very high, they change the color of the water to green or brown. This is called a "bloom."

kalo; taro **Introduced**
(Colocasia esculenta)

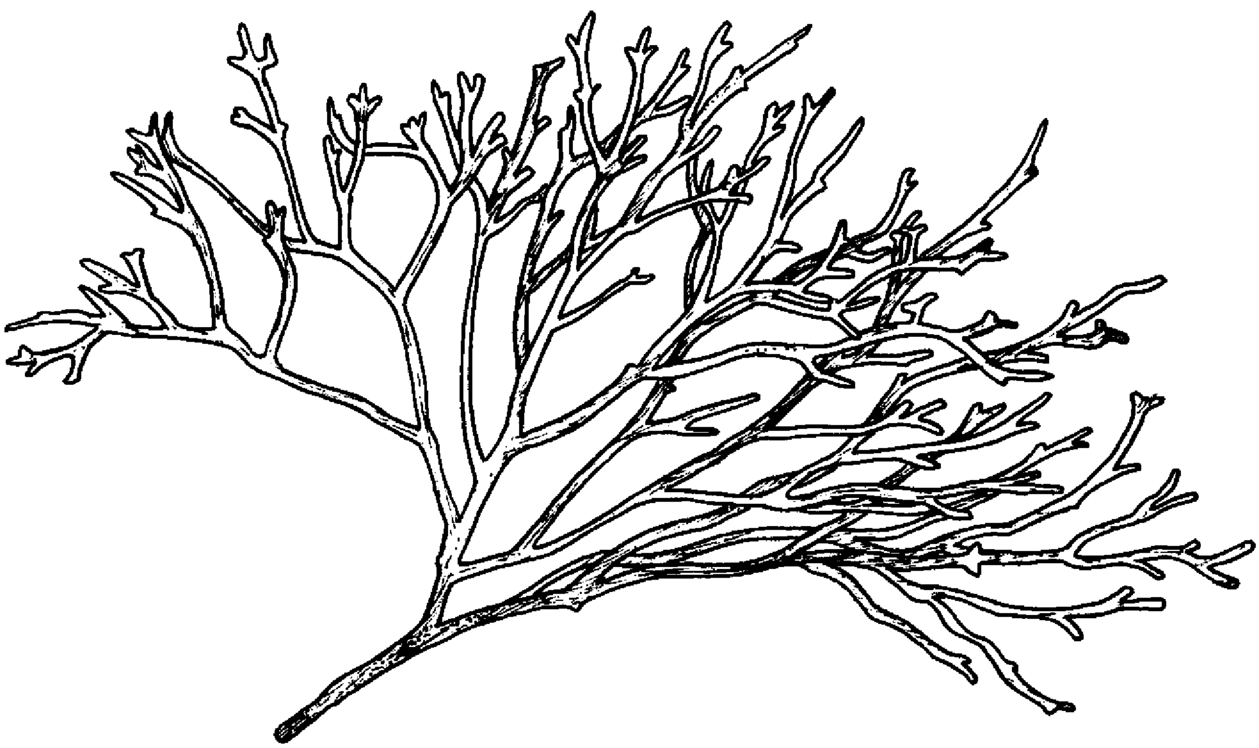
Eaten by: humans, pigs; in cooked form it was used as chum for ʻamaʻama, awa, and uhu

Description: long-stemmed plant with heart-shaped green or red leaves; major staple crop in old Hawaiʻi

Habitat: wetland kalo is found along stream banks, marshy areas, freshwater springs, or loʻi (taro terraces); dryland kalo prefers shady areas where annual rainfall exceeds 50 in. per year.

Did you know? According to Hawaiian beliefs, kalo is an ancestor of the Hawaiian people. It was the most important food crop in old Hawaiʻi. Stone walls from ancient loʻi are still visible in valleys all over the islands. Poi, which is made by steaming and pounding the kalo corm, is an essential part of the Hawaiian diet. It is often referred to as the best food for "babies and old people without teeth." Today kalo is also used as an ingredient in other products such as mochi, lavosh, chips, bread, and kūlolo. Many parents still say "Don't fight in front of the poi bowl," meaning respect your elders.

Producer



Producer

limu kala **Endemic**
(Sargassum echinocarpum)

Eaten by: surgeonfishes (particularly kala, which gets its name from eating this alga)

Description: golden brown, bushy, with small inflated gas bladders; smooth blades (leaf-like parts) have a leathery texture and are usually 1 - 4 in. long, 1/2 in. wide with toothlike edges; (It looks a little like holly.)

Habitat: tide pools and reef flats, exposed areas with wave action, rocky and sandy places where there are intruding rocks; found throughout the Pacific

Did you know? "Kala" means to loosen, remove or forgive. Limu kala is used in Hawaiian rituals to settle disputes (ho'oponopono). Limu kala is also the first food given to a mother after childbirth to loosen or remove any hidden disease in her or her child. A lei of limu kala, worn open at the bottom, is used to remove disease as well. A person who is almost recovered from a lingering illness wears the limu kala lei and walks out into the ocean to let the waves carry the lei and the sickness away. Limu kala is also chopped or chewed and applied to wounds as a poultice to aid in healing.

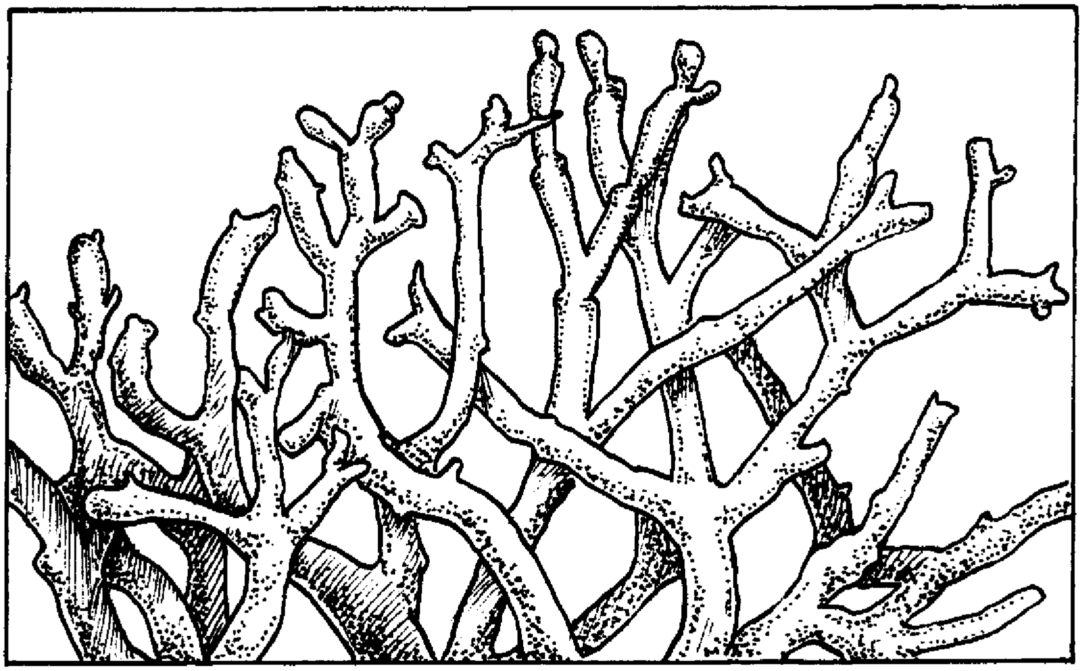
limu manauea **Endemic**
ogo (Japanese name)
(Gracilaria coronopifolia)

Eaten by: humans, pualu, manini

Description: red alga with many "branches"; grows 4 - 6 in. tall in crisp clumps with a rounded top; it sometimes has a greenish cast.

Habitat: shallow reefs, sandy areas, and the seaward sides of more salty loko i'a. Before the 1960s it was found also in rocky areas where there is sand and a stream nearby.

Did you know? Women and children gathered limu in old Hawai'i by collecting plants that had washed ashore or by wading out to collect at low tide. When limu was cut from rocks with a bamboo knife, it was important to leave the bottom part of the plant, called the holdfast, attached to the rock so that a new plant could grow. Today, a kapu is placed on taking limu with the holdfast as well as taking limu that has reproductive nodes or bumps. Limu manauea has a mild favor and crunchy texture. This limu is chopped and added to raw fish to make poke. It tastes good and adds iodine and multi-vitamins to the diet.



Producer

Producer

Limu: red algae **Introduced**
(*Gracilaria salicornia*) Tropical Indian/Pacific Oceans

Eaten by: humans, perhaps reef animals, but it is not certain which ones

Description: bright yellow or orange in sunlight, greenish to dark brown in shade; forms dome-shaped clumps up to 12 in. across and 4 in. high; the stems are round, thick, and jointed.

Habitat: *Gracilaria salicornia* is very invasive, thriving in rocky intertidal areas, tidepools, reef flats, and seaweed beds, to a depth of 15 ft; it is often found tangled with other types of seaweeds or limu.

Did you know? Just a tiny piece of this alga can grow into a new clump. It can form a thick mat, covering the reef and blocking sunlight, which kills the coral and reef micro-organisms. It was planted in Hilo Bay and waters off Waikīkī during the 1970s as a possible food product and for medical research. The clumps are a threat to the corals and native limu (algae) on which many marine animals depend for food and shelter. This seaweed has the potential to damage our fragile marine environment. Some people add it to their poke because it's crispy, but no studies have been done to see if any marine animals in Hawai'i like to eat it.

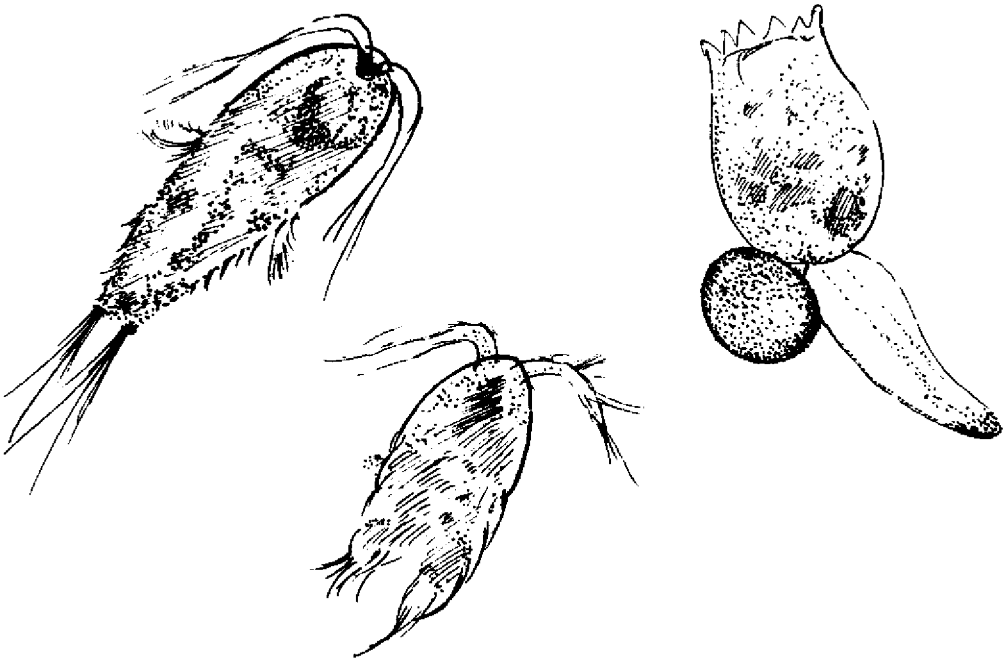
Limu; spiny seaweed **Introduced**
(*Acanthophora spicifera*) All Tropical Oceans

Eaten by: honu, manini, yellow tang, sea urchin

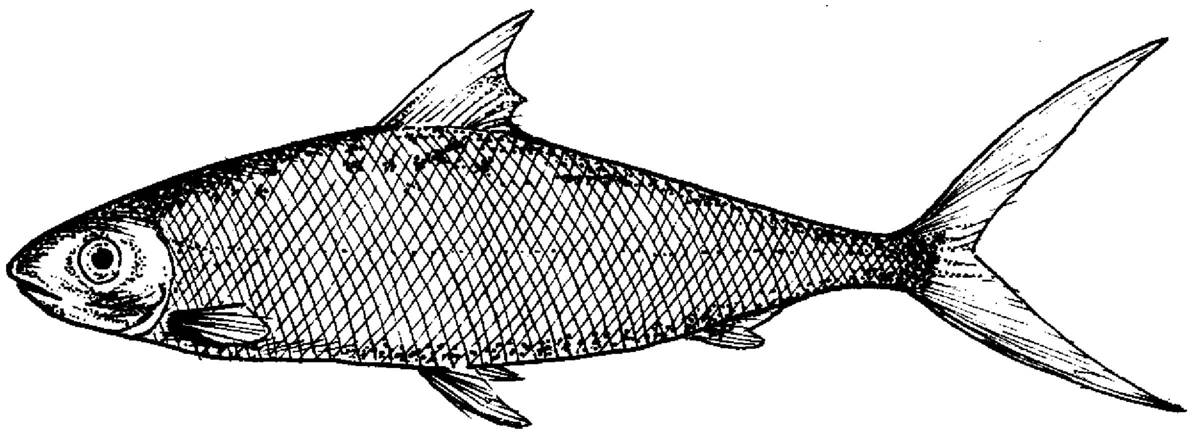
Description: reddish, olive-green, or brown, turning yellowish in bright sun; this seaweed has many short spiny fragments and many short fragile branches; the branches have crown-shaped tips with tight clusters of pointed projections.

Habitat: It grows in areas with rocky bottoms, in calm, shallow reef flats, tidepools, and rocky intertidal benches that are swept by small waves; or it can be free-floating.

Did you know? *Acanthophora spicifera* has become the most common invasive seaweed worldwide. This seaweed is native to Florida and the Caribbean. It is an invader to Hawaiian waters and has been shown to compete with our native limu species. It is thought to have arrived in the Islands on the bottom of a barge from Guam in the 1950s. Its survival on reefs is greater when it grows with other limu (algal) species that are more tolerant of wave exposure and are able to retain water when exposed to air. This seaweed has been studied for its anticoagulant (a substance that slows the clotting of blood) and antiviral properties.



Herbivore



Herbivore

zooplankton **Endemic**
(Copepoda sp.)

Eats: phytoplankton

Eaten by: shrimp, young fish, such as ʻoʻopu and āholehole

Description: copepods are flea-shaped crustaceans that are only about 1 mm long. They are the most common zooplankton found in Hawaiian fishponds. Zooplankton swim or drift through clouds of phytoplankton, grazing on the cells that contact their feeding appendages.

Habitat: fresh, brackish, and salt water

Did you know? The tiny zooplankton are easy to miss in the fishpond, but they are the second major link in the food web. They are choosy about the type of microalgae they eat, but they still eat enough to cut back the phytoplankton population during certain times of the year. Phytoplankton and zooplankton bloom and decline, linked together in a cycle that has existed over millions of years.

awa; milkfish **Indigenous**
(*Chanos chanos)* East Africa to the Americas

Eats: phytoplankton, limu, detritus

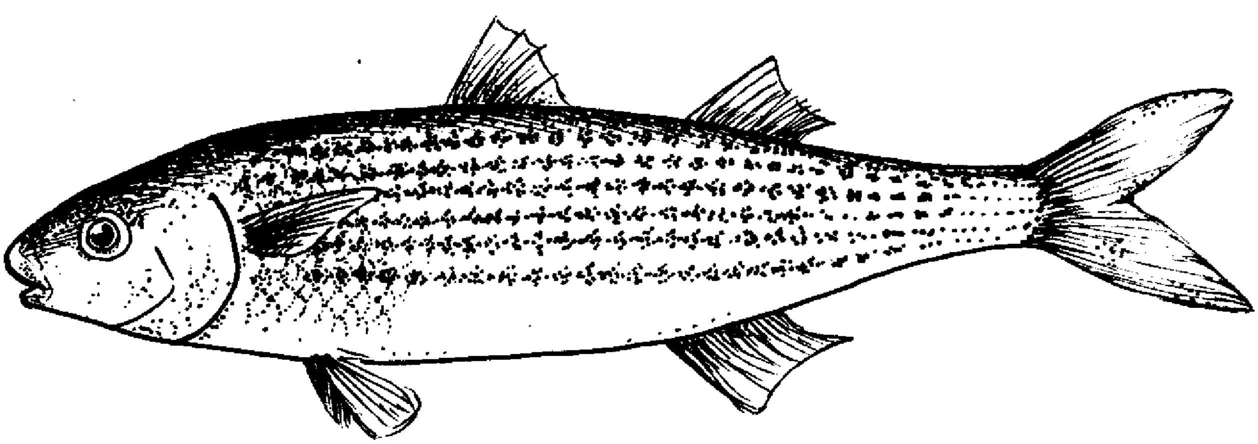
Eaten by: humans, kākū, moi, ulua

Description: silver in color with a small pointed mouth, deeply forked tail and a single, almost shark-like dorsal fin; grows to 6 ft.; average size 12 - 14 in.

Habitat: often enters shallow water to feed on algae and frequents deeper reef areas

Did you know? This indigenous fish adapts well to being raised in fishponds. It was prized along with the ʻamaʻama for its delicious flavor. Some aliʻi (chiefs) reserved the well-fattened awa for their use if the supply was limited.

Herbivore



Herbivore

nahawele; Hawaiian mussel **Endemic**
(Brachidontes crebristriatus)

Eats: phytoplankton

Eaten by: crabs, puffer fish, mantis shrimp

Description: a bivalve or mollusk with two opposing shells; dark purple-brown in color; nahawele li‘i li‘i (small mussels) are 1/4 - 1/2 in. long; adults grow up to 1 in. or more in brackish waters

Habitat: in brackish water or on the seashore where there is some fresh water; in dense beds on waved-washed shores at 0 or low-tide water mark; usually half-buried or attached to rocks

Did you know? The largest nahawele grow in brackish water environments. These mussels are sometimes called mahawele.

‘ama‘ama; striped mullet **Indigenous**
(Mugil cephalus) Pacific

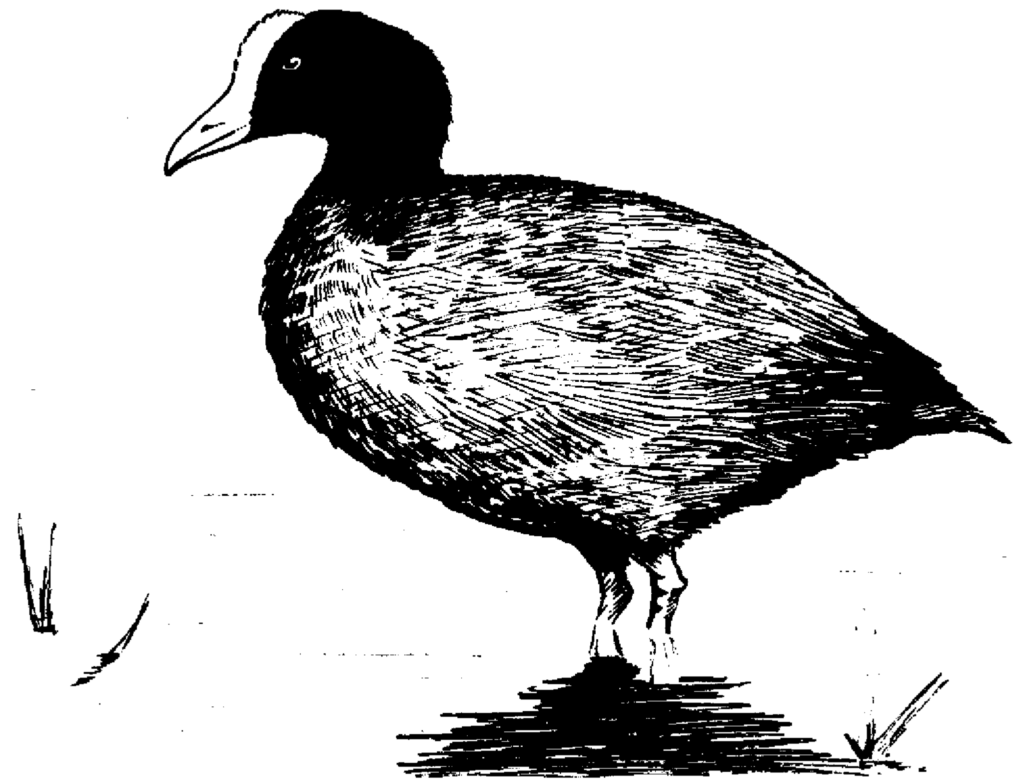
Eats: phytoplankton, diatoms and detritus; feeds primarily off the bottom, taking in sand and filtering out the organic material through its gills

Eaten by: humans, kākū, moi, ulua

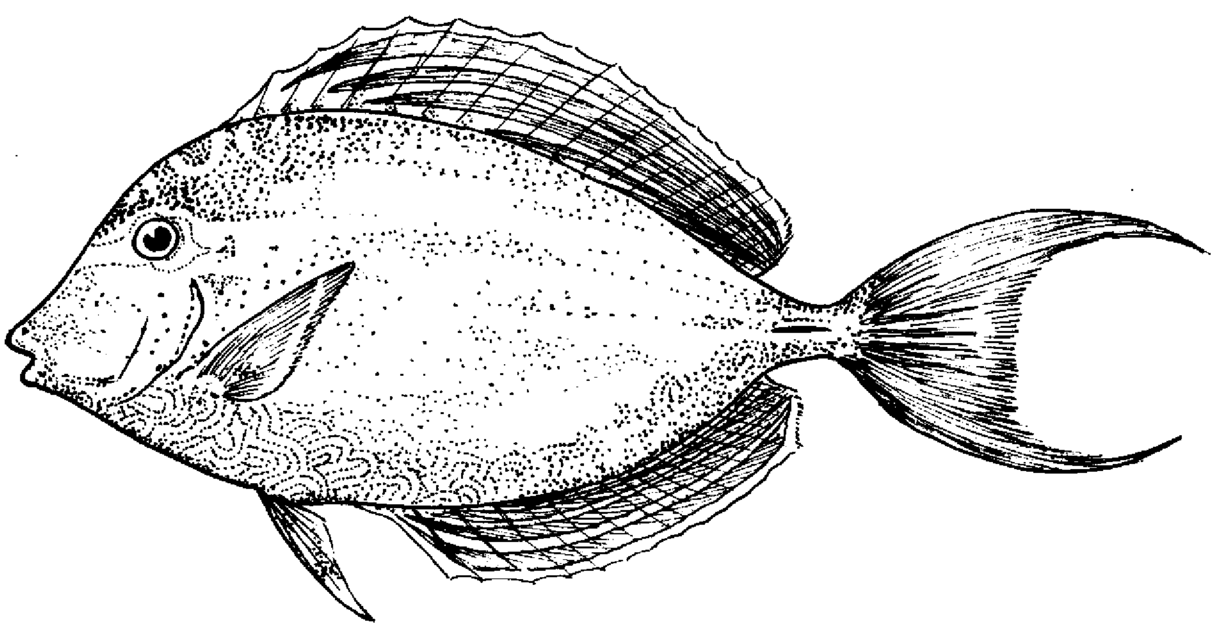
Description: silvery or gray with long body that is round or oval in cross section; has characteristic blue spot at the base of the pectoral fin; has blunt snout, a flattened head and large scales and two widely separated dorsal fins; lacks teeth of any distinction; can grow to 18 in.

Habitat: shallow, often brackish coastal waters, easily raised in fishponds

Did you know? Mature ‘ama‘ama are called ‘anae. ‘Anae go to the open ocean to spawn from December - February. Wai‘anae is literally “mullet water.” Hawaiians referred to ‘ama‘ama as “pua‘a kai” (sea pig) and used them when a pig was not available for ritual offerings.



Omnivore



Omnivore

'Alae ke'oke'o; Hawaiian coot **Endemic**
(Fulica Americana alai) Endangered

Eats: submerged aquatic plants, limu alolo, small fish and insects

Eaten by: dogs and cats; mongooses and 'auku'u; (chicks are also eaten by rats)

Description: black bird with white rump and white frontal shield; dark legs with lobed toes; pointed, chicken-like light colored bill

Habitat: saltwater and freshwater ponds and open marshes where it can dive for food

Did you know? These endangered waterbirds build their nests among the grasses around a pond where predators can attack! Be sure to keep your dogs on a leash if you walk near a pond where birds could be nesting. According to Hawaiian legend, the sacred 'alae are children to the goddess Hina.

pualu; yellowfin surgeonfish **Indigenous**
(Acanthurus xanthopterus) East Africa to the Americas

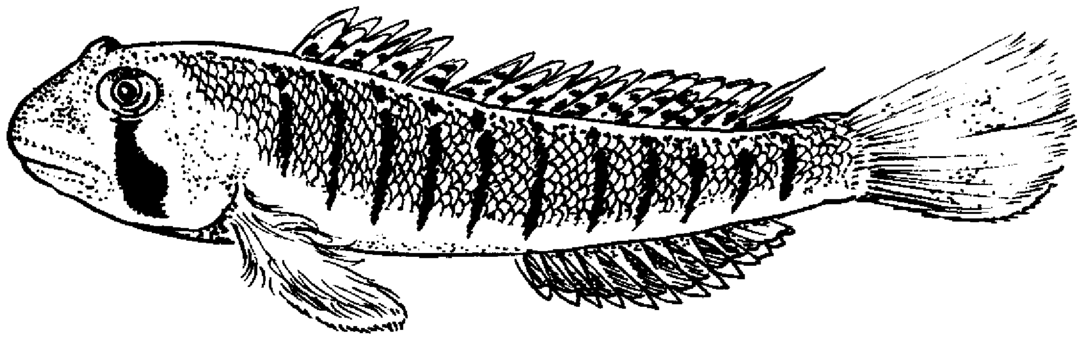
Eats: phytoplankton and zooplankton (when young), limu growing on sandy bottoms

Eaten by: larger carnivorous fish

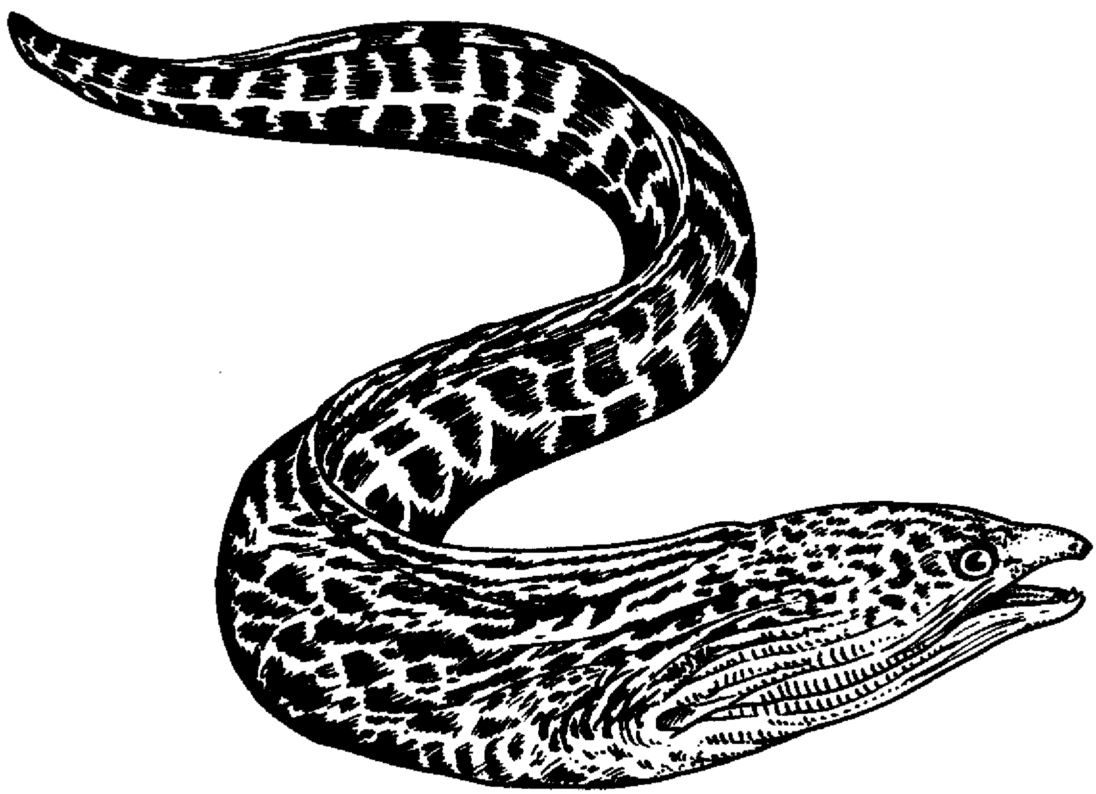
Description: oval, compressed (thin) body; purplish gray with yellow and blue banded dorsal (back) and anal fins; has a black caudal (tail) spine and two knifelike spines or scalpels at the base of the tail; grows to 22 in.

Habitat: shallow waters with sandy bottoms

Did you know? The yellow pectoral fins are important for identification of the pualu since it can alter its body color to almost black with a white ring around the tail. The pualu uses the two knifelike spines at the base of its tail to defend itself and to help capture prey.



Omnivore



Carnivore

'o'opu naniha; goby **Endemic**
(Stenogobius hawaiiensis)

Eats: limu, worms, shrimp, small crabs, zooplankton, insect larvae

Eaten by: humans, ulua, moi, kākū, pūhi

Description: yellow-brown with black stripe extending down below eyes; 4 - 5 in long; both sexes display black bars on bodies and red border on edge of dorsal fins during courtship; has suction disc, but does not climb beyond lower reaches of streams.

Habitat: stream bottom in lower reaches of streams

Did you know? This 'o'opu feeds by thrusting its snout into the sediments of the stream bottom. If you see a stream bottom with many tiny craters, this is a clue that naniha has been feeding there. In olden times, fishers gave offerings to the 'o'opu fish god named Holu. If they did not provide offerings, such as a black pig, a white chicken, root of the black awa, dark coconut, or red fish, it was believed that the 'o'opu would not be fat or plentiful.

pūhi-lau-milo; undulated moray eel **Indigenous**
(Gymnothorax undulates) East Africa to the Americas

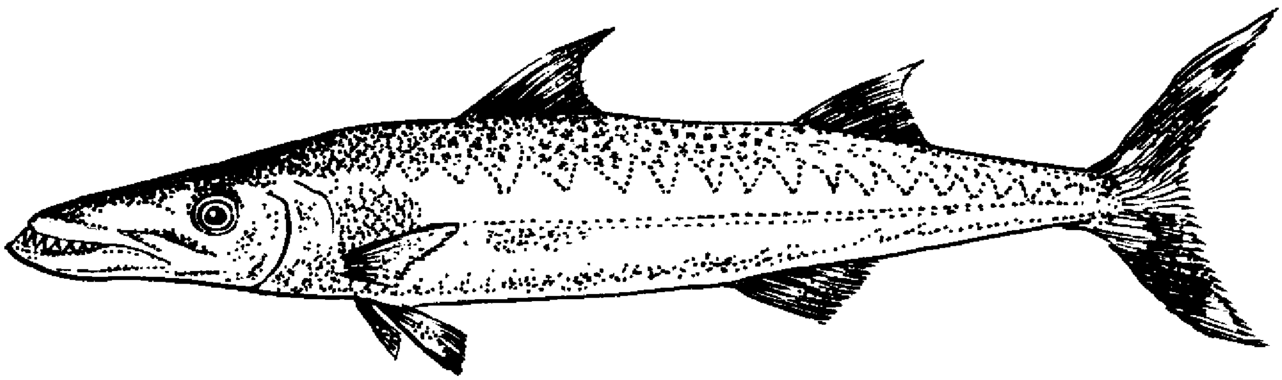
Eats: smaller fish, shrimp, crabs

Eaten by: ulua

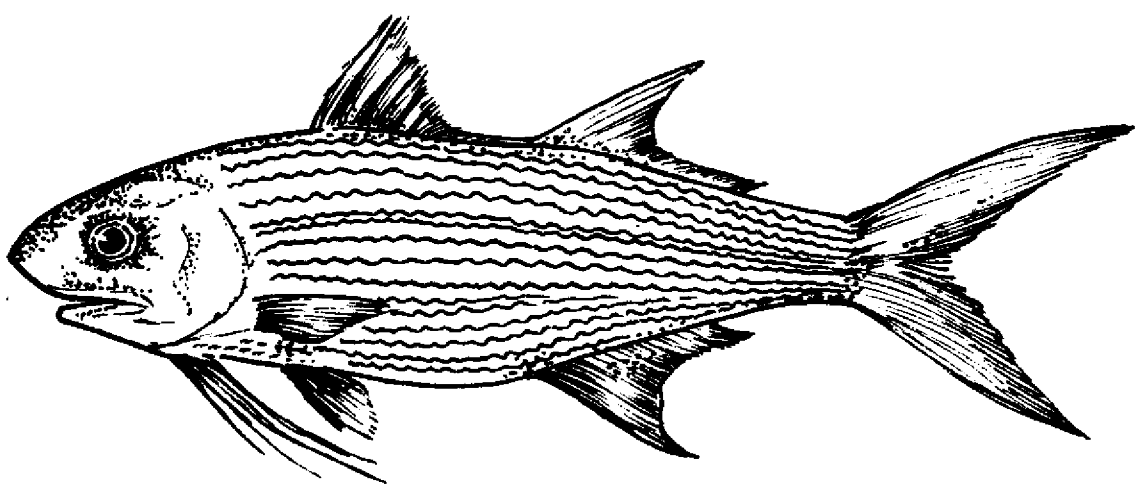
Description: 3 - 5 ft. long muscular body has tough slippery, skin without scales; has narrow jaws full of long sharp teeth, including a row down the center of the mouth; top of head is sometimes greenish-yellow; body color varies from dark brown with light speckles and irregular vertical net-like markings to the reverse, almost white with irregular brown blotches; larvae are long, clear and ribbon-like.

Habitat: lives in crevices and holes, and in spaces between the rocks in walled-fishponds

Did you know? ***You should not attempt to play with or feed this pūhi; it can hurt you!*** It has a strong sense of smell and is more active at night. This predator can also survive on only one meal for a long time.The Hawaiian name means leaf of the milo tree. Why do you think it has that name? Hawaiians caught this pūhi using nets, spears and hooks. It is an 'aumakua (personal god) for some families.



Carnivore



Carnivore

kākū; great barracuda **Indigenous**
(Sphyraena barracuda) Indo-Pacific and Atlantic

Eats: smaller fish

Eaten by: humans, ulua

Description: silvery, long, round in cross-section, with a pointed, protruding lower jaw, two dorsal fins spaced widely apart; has a large forked tail; often has small black blotches irregularly placed on the lower side; grows to almost 6 ft.

Habitat: occurs alone or in small groups, often found in shallow water close to shore; gets into fishponds where it feeds on other fish

Did you know? In Puna on the island of Hawai'i, the kākū is said to have bumped against canoes, usually at night when there were lights shining from the boats. Since olden times, mahi'ai (fishers) have had a special relationship with the kākū. The mahi'ai tamed certain large kākū called 'ōpelu mama by hand-feeding them. Then they trained the tamed kākū to help catch 'ōpelu. The fisher summoned his kākū by pounding in rhythm on the bottom of the canoe. His fish would swim up from the deep and follow the canoe to a school of 'ōpelu. Then fishermen lowered a large circular net and fed the 'ōpelu with cooked, grated squash. The kākū would circle the school of fish and drive them into a tight ball and then the net would be raised full of fish. The fishermen would toss the 'ōpelu mama a fish as a reward. This way of fishing is still practiced on Maui.

moi; threadfin **Indigenous**
(Polydactylus sexfilis) Indo-Pacific

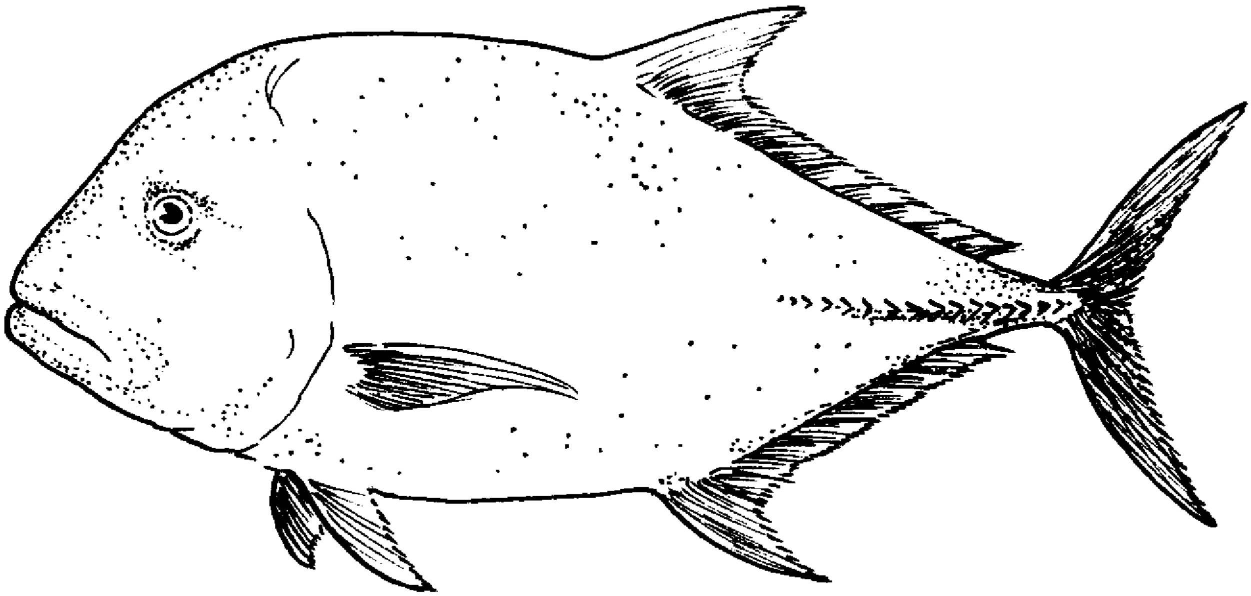
Eats: small fish, shrimp, crabs

Eaten by: humans, kākū, ulua

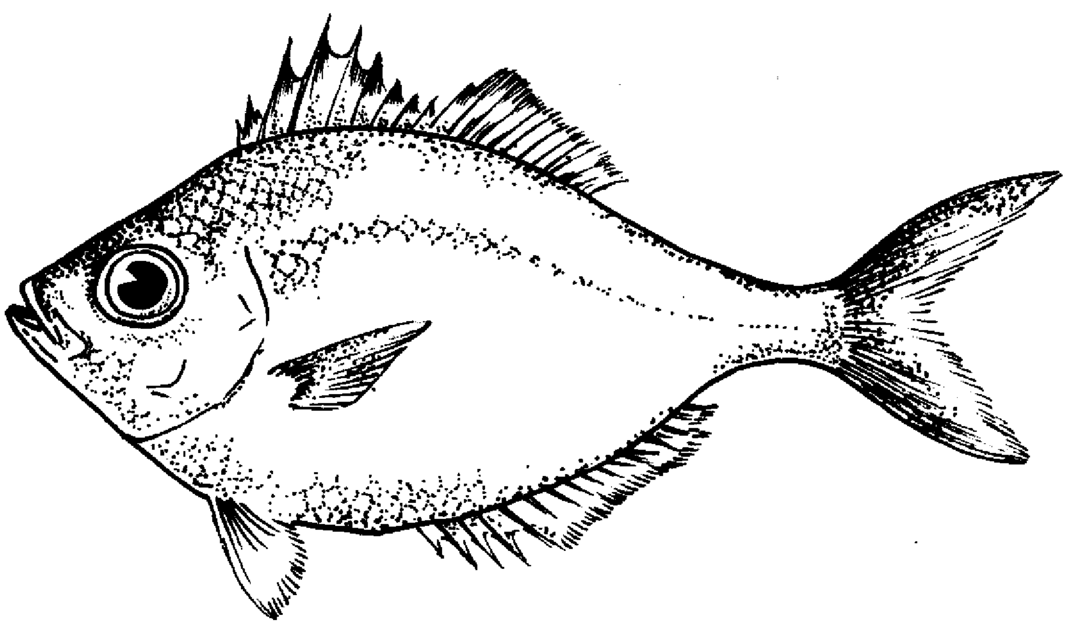
Description: silver in color; has six threadlike rays on the pectoral fins; a bulbous snout; underslung mouth; distinctive sweptback fins and a deeply forked tail; grows to about 12 in. Adults are called moi; juveniles are called moi li'i.

Habitat: Adult moi are commonly found along rugged coastal shorelines with strong wave action; juveniles are found over calmer, nearshore areas with sandy bottoms; does not swim at the surface.

Did you know? In olden days, large schools of moi were said to foretell disaster of chiefs. Moi are delicious to eat; they were highly prized by the ali'i (chiefs) and kapu to commoners. Schools of young moi (moi li'i) can be spotted close to shore from mid-August through October. 'Ehu moi refers to foam of sea where moi are found. Fishers call this fish the wily moi because it is difficult to catch.



Carnivore



Carnivore

ulua aukea; pāpio; giant trevally **Indigenous**
(Caranx ignobilis) Indo-Pacific

Eats: smaller fish, and forages on the bottom for crustaceans and other invertebrates

Eaten by: humans

Description: silvery on the sides and undersides and bluish or greenish on the back with deeply forked tails. The narrow place at the base of the tail is reinforced by specially strengthened scales called scutes; grows to over 5 ft. with a weight of up to 200 pounds.

Habitat: schools of ulua frequently patrol reefs; young fish (less than 4 in.) swim in protected bays and ponds.

Did you know? There is a Hawaiian proverb spoken in admiration of a warrior who does not give up without a struggle. ʻAʻohe ia e loaʻa aku, he ulua kāpapa no ka moana. (He cannot be caught for he is an ulua fish of the deep ocean.) The ulua's color pattern, like that of many marine animals, is dark on top and light below. This counter-shading camouflages it in open water. In the Hawaiian name, ulua aukea, "kea" means white. In old Hawaiʻi, this prized fish could be substituted for a human in a ceremony calling for a human sacrifice. This may have been because the word ulua refers to "man" or "sweetheart" in love songs. Hawaiian women were forbidden to eat ulua.

āholehole; Hawaiian flagtail **Endemic**
(Kuhlia sandvicensis)

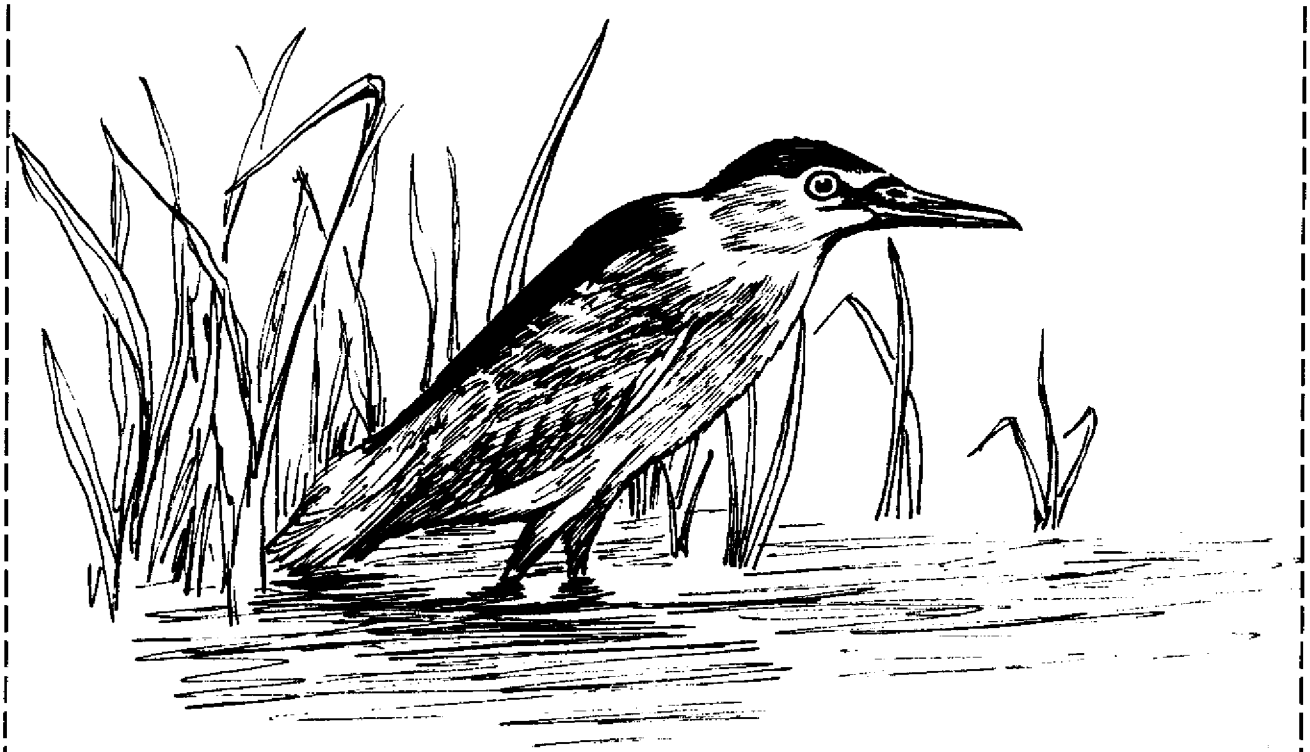
Eats: small fish, small crabs and shrimp, insect larvae

Eaten by: humans, larger carnivorous fish, ulua, kākū, eels

Description: bright silvery with bluish color on back, but changes color to match habitat; large scales and large eyes; 6 - 10 in. long

Habitat: juveniles in lower reaches of streams; adults in brackish water, tidal pools, and holes along the outer edges of the reef

Did you know? Āholehole means "sparkling" in Hawaiian. In the adult stage, it is called āhole. Hawaiians placed āholehole under house posts on the east side to keep away a kahuna who might predict trouble for the family. Hawaiians also placed offerings of a white ʻamaʻama or āholehole along with a red weke or kumu under the entrance of a new hale (home) to strip evil away. "Hole" in āhole means "to strip away." According to one story, a chiefess in Hilo yearned for āholehole from Waiʻakolea in distant Puna. A runner delivered the fish to her wrapped in limu kala from the fishpond, and the fish was still breathing!



Carnivore

Carnivore

'auku'u; black-crowned night heron **Indigenous**
(Nycticorax nycticorax hoactli) Americas, Africa, Eurasia and the Pacific

Eats: small fish, shrimp, larvae of aquatic insects, and young chicks of other water birds

Eaten by: when young, injured or sick, this bird might be eaten by dogs, cats and mongoose

Description: has a glossy greenish black coloring on its back, feathers and on the top of the head; the under parts are white; neck, wings, and legs are all long; looks hunched over with its head usually tucked down to its shoulders. Adults are 23 - 26 in. tall with a wingspan of 43 - 45 in. wide.

Habitat: marshes, ponds, streams, lagoons, swamps, exposed reefs, and tide pools; also frequents aquaculture sites. It lives on all the main islands except Lāna'i. The call of the night heron is a hoarse "quok."

Did you know? Hawaiians call someone who spies on others, "'Auku'u kia'i loko" (Heron who watches the [fish in the] pond). The 'auku'u are very intelligent birds with very sharp eyesight, which allows them to escape from predators. They are nocturnal as indicated by the name night heron. At aquaculture sites, they know when it's pau hana. They can be seen flying onto pond fields and shrimp farms when the workers drive away.

aloalo; white mantis shrimp **Indigenous**
(Oratosquilla calumnia) Indo-Pacific

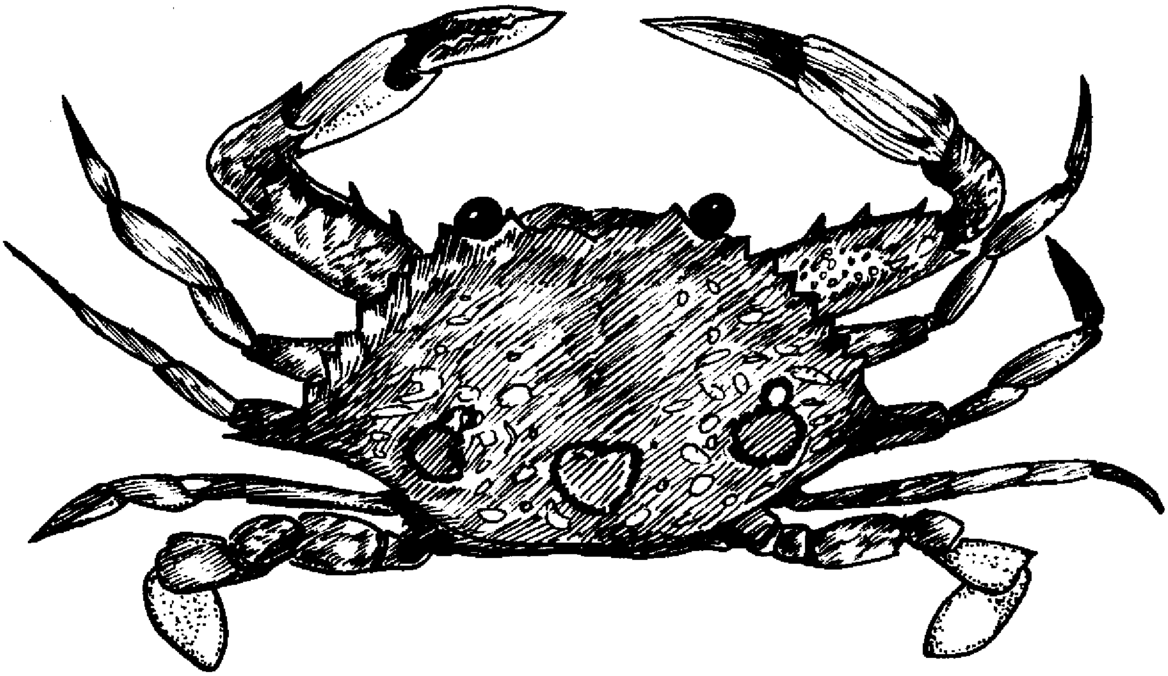
Eats: soft-bodied worms, shrimp, small fish, crabs, snails

Eaten by: humans, puffer fish, ulua, moray eels

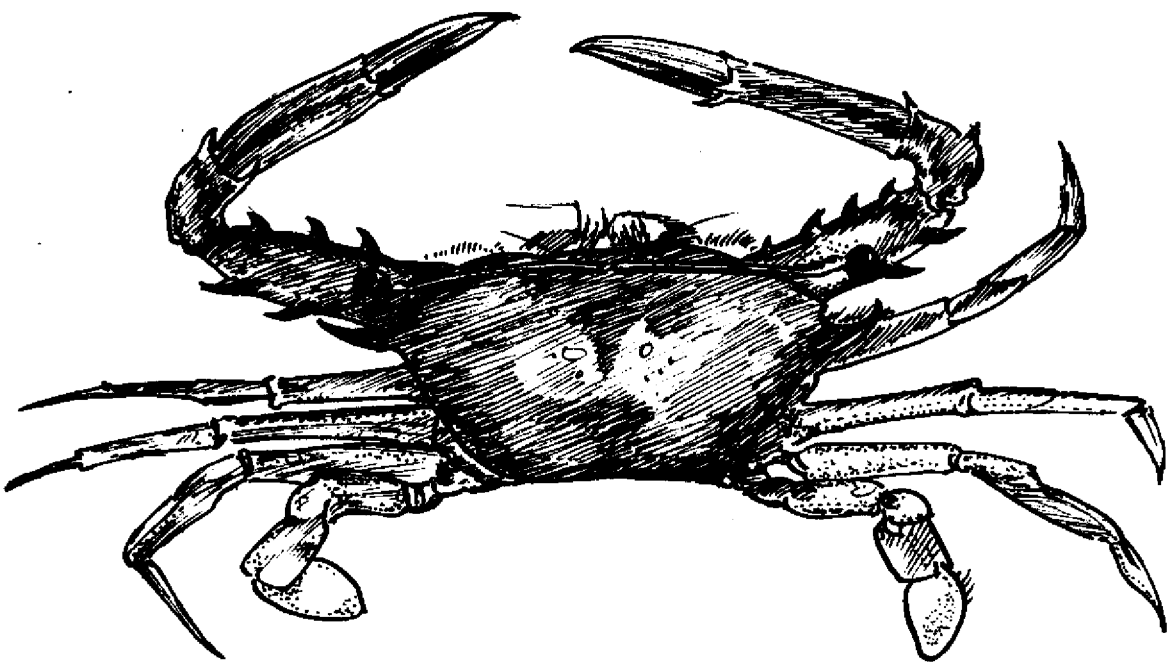
Description: ***dangerous*** bottom-dwellers; light transparent gray, tan, or reddish brown with dark marks on the appendages on either side of the tail; has eight pairs of legs, the last three are used for walking; grows to 6 - 8 in.

Habitat: lives in muddy, sometimes brackish water areas in U-shape burrows

Did you know? You should not attempt to catch this shrimp with bare hands! They are aggressive carnivores that smash or spear their prey. Their pincers are folded up under their body and when they use them to strike prey, it's one of the fastest movements known in the animal kingdom!



Decomposer



Decomposer

kūhonu; white crab; haole crab; blood-spotted swimming crab — **Indigenous**, Indo-Pacific

(Portunus sanguinolentus)

Eats: dead or dying fish, small shrimp, worms

Eaten by: pūhi, kākū, ulua, moi

Description: has strong sideways-pointing spine on each side of the carapace, which is the hard shield covering part of the body; carapace is marked with three red spots; can attain up to 7 in. across the carapace and an 'arm-spread' of 18 in.

Habitat: sandy, muddy areas from the shorelines to depths of 100 ft. This species is protected by law and can only be gathered if the carapace is at least 4 in. wide.

Did you know? The Hawaiian name of this crab, kūhonu, means "turtle back."

mo'ala; long-eyed swimming crab — **Indigenous**, Indo-Pacific

(Podophthalmus vigil)

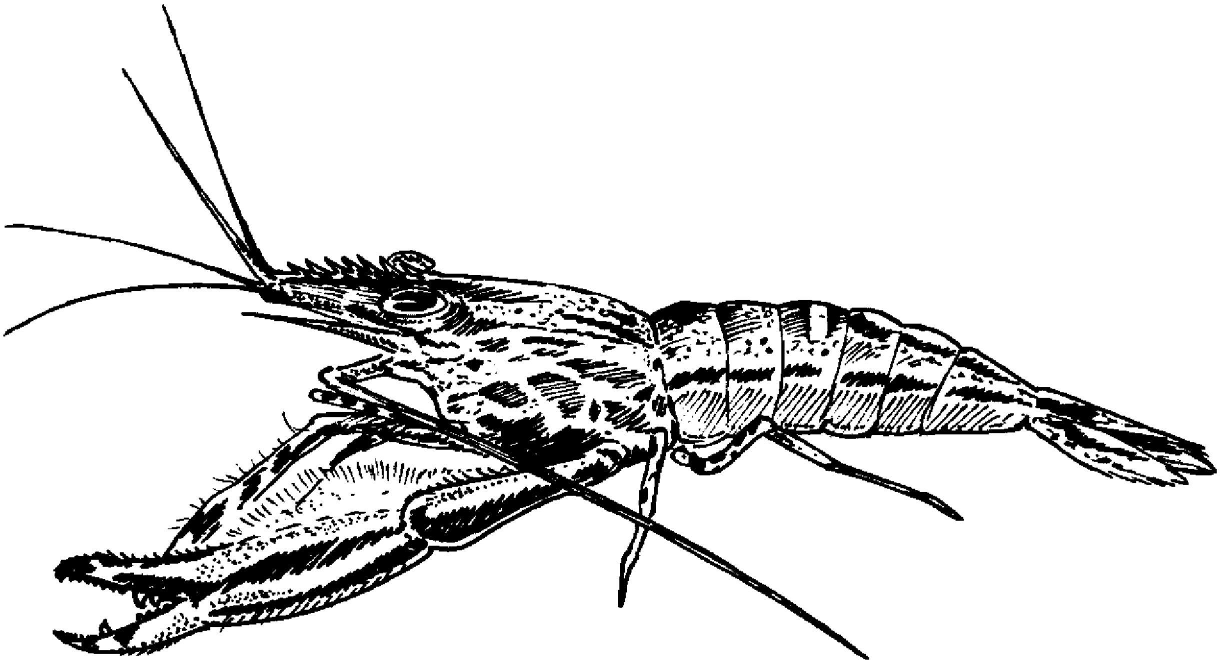
Eats: dead or dying fish, small shrimp, worms

Eaten by: pūhi, kākū, ulua, moi

Description: the eyestalks of this crab are amazingly long and can either be held direct or folded back into grooves along the front of the carapace. Individuals are brown to pinkish in color; grows to about 5 in. (carapace width).

Habitat: lives on soft muddy bottoms and can tolerate brackishwater conditions

Did you know? The Latin species name of this crab means "watchful." These crabs are seldom seen by divers and snorkelers because of their habitat.



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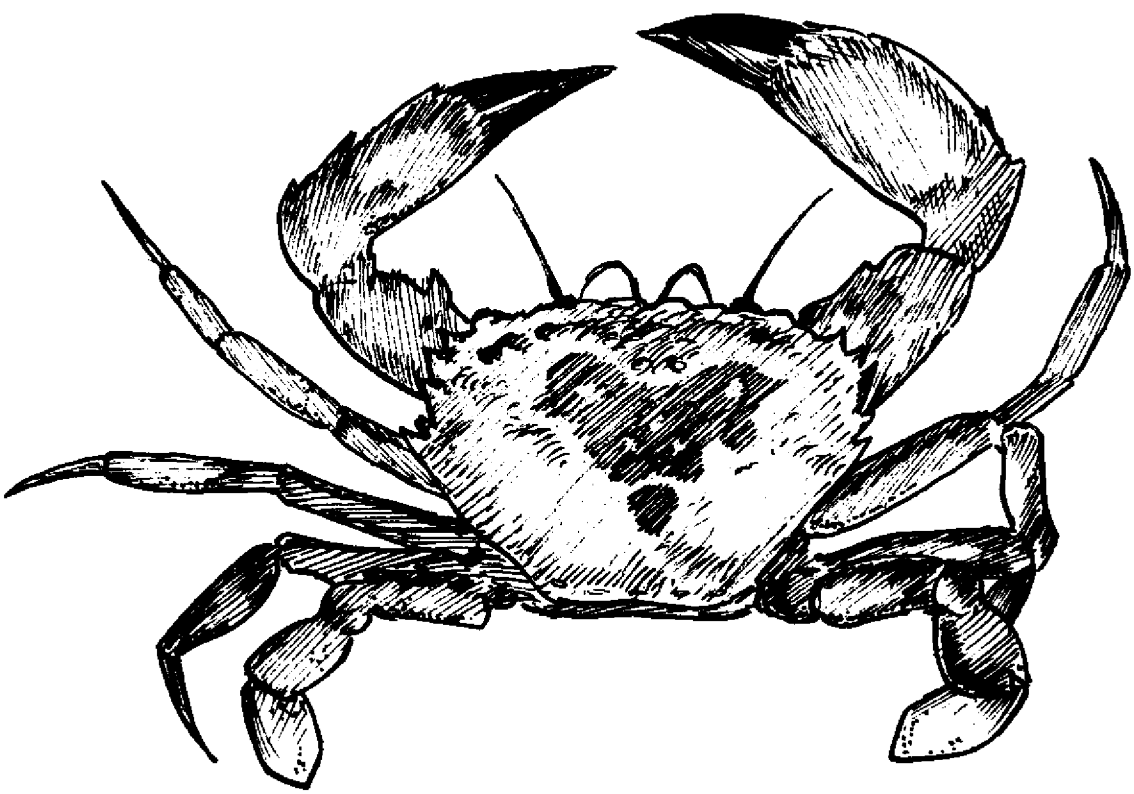


Decomposer

ʻōpaeʻoehaʻa; freshwater prawn **Endemic**
(Macrobrachium grandimanus)

Eats: detritus; small pieces of plant and animal matter

Eaten by: humans, moi, pāpio

Description: light to dark brown; one pincer is larger than the other; has distinctive striped pattern; 3 in. long

Habitat: lower reaches of streams and estuaries

Did you know? The Hawaiian name ʻoehaʻa means "to walk crookedly" which describes the uneven gait of this native prawn as it walks with its one large and one small claw. The female ʻōpae carries her eggs attached to modified swimmerets under her tail. When the eggs hatch about 3 to 4 weeks later, the tiny larvae go downstream, out to sea. They develop further in the ocean and then make their way back up to a stream where they spend their adult lives.

pāpaʻi; blue pincher crab **Indigenous**
(Thalamita crenata) Indo-Pacific

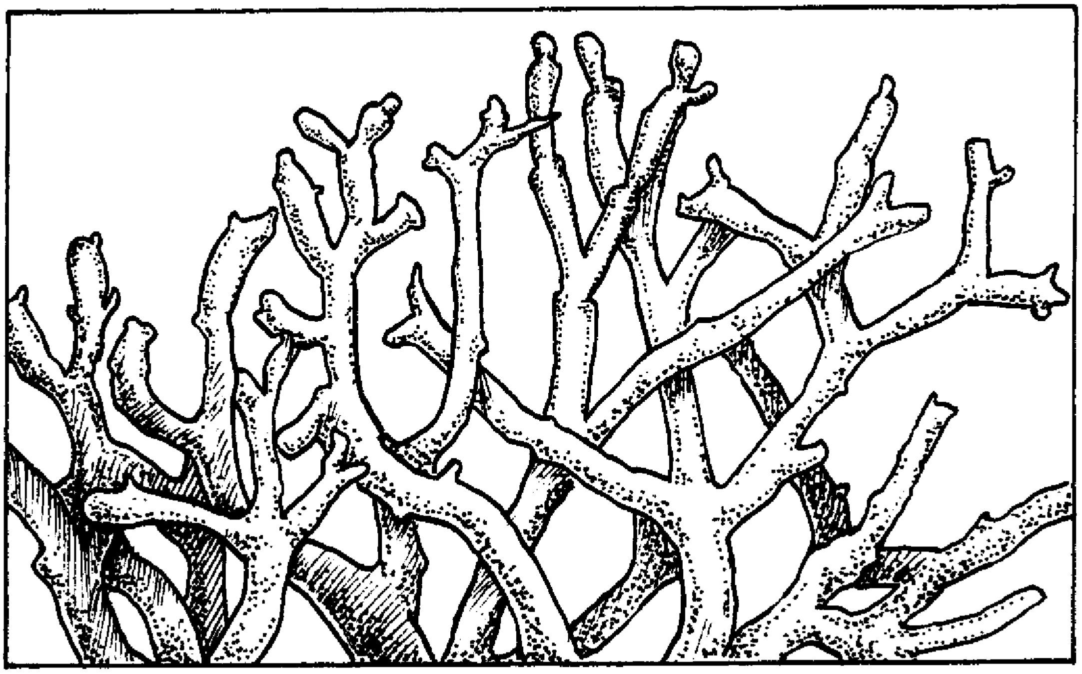
Eats: limu, mangrove detritus; small pieces of plant and animal matter, snails; eats more in quantity and more animal matter at spring tide, low tide, and during daytime

Eaten by: humans, pāpio, pūhi, moi

Description: gray- to greenish-brown, sometimes pink body; white-tipped claws have a broad black band; upper segment of pincers are blue; grows to a carapace width of 5 in.

Habitat: sandy, muddy areas in brackish and salt water

Did you know? Unlike most swimming crabs, the blue pincher crab forages for prey more actively during the daytime. Scientists have found that, just like people, the blue pincher crabs may use landmarks to find their way home. When these crabs are removed from their home hole, they rely on their memory and knowledge of the space around them to find their way home! These crabs also have a more flexible way of orienting themselves than other crabs.



Producer

Producer

Limu: red algae | **Introduced**
(Gracilaria salicornia) | Tropical Indian/Pacific Oceans

Eaten by: humans, perhaps reef animals, but it is not certain which ones

Description: bright yellow or orange in sunlight, greenish to dark brown in shade; forms dome-shaped clumps up to 12 in. across and 4 in. high; the stems are round, thick, and jointed.

Habitat: *Gracilaria salicornia* is very invasive, thriving in rocky intertidal areas, tidepools, reef flats, and seaweed beds, to a depth of 15 ft; it is often found tangled with other types of seaweeds or limu.

Did you know? Just a tiny piece of this alga can grow into a new clump. It can form a thick mat, covering the reef and blocking sunlight, which kills the coral and reef micro-organisms. It was planted in Hilo Bay and waters off Waikīkī during the 1970s as a possible food product and for medical research. The clumps are a threat to the corals and native limu (algae) on which many marine animals depend for food and shelter. This seaweed has the potential to damage our fragile marine environment. Some people add it to their poke because it's crispy, but no studies have been done to see if any marine animals in Hawai'i like to eat it.

Limu; spiny seaweed | **Introduced**
(Acanthophora spicifera) | All Tropical Oceans

Eaten by: honu, manini, yellow tang, sea urchin

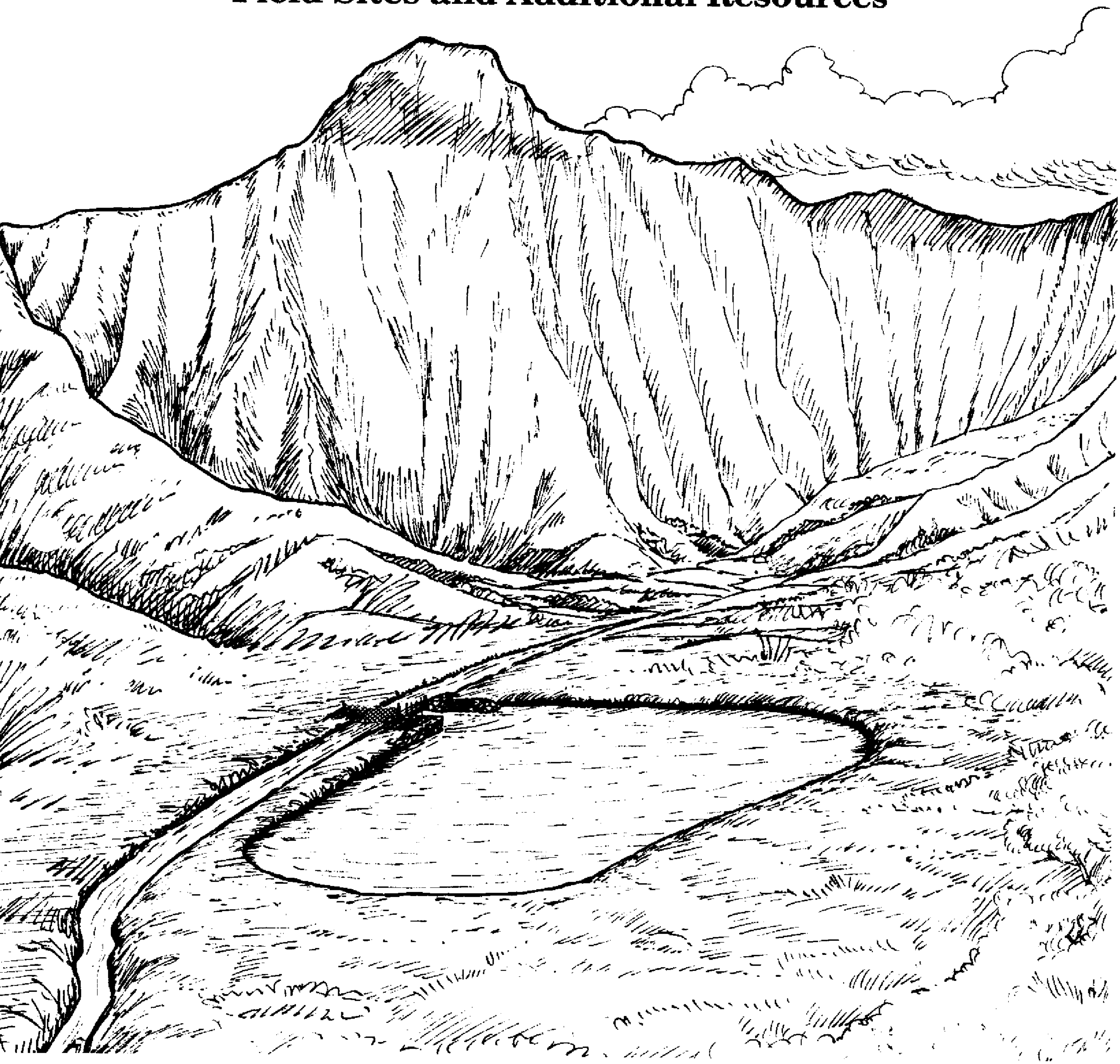
Description: reddish, olive-green, or brown, turning yellowish in bright sun; this seaweed has many short spiny fragments and many short fragile branches; the branches have crown-shaped tips with tight clusters of pointed projections.

Habitat: It grows in areas with rocky bottoms, in calm, shallow reef flats, tidepools, and rocky intertidal benches that are swept by small waves; or it can be free-floating.

Did you know? *Acanthophora spicifera* has become the most common invasive seaweed worldwide. This seaweed is native to Florida and the Caribbean. It is an invader to Hawaiian waters and has been shown to compete with our native limu species. It is thought to have arrived in the Islands on the bottom of a barge from Guam in the 1950s. Its survival on reefs is greater when it grows with other limu (algal) species that are more tolerant of wave exposure and are able to retain water when exposed to air. This seaweed has been studied for its anticoagulant (a substance that slows the clotting of blood) and antiviral properties.

APPENDIX

Field Sites and Additional Resources



Fishpond Field Sites

Kaua'i

Nāwiliwili

Site: 'Alekoko or Menehune Fishpond
Type of Pond: loko wai
Coordinator: TBA

O'ahu

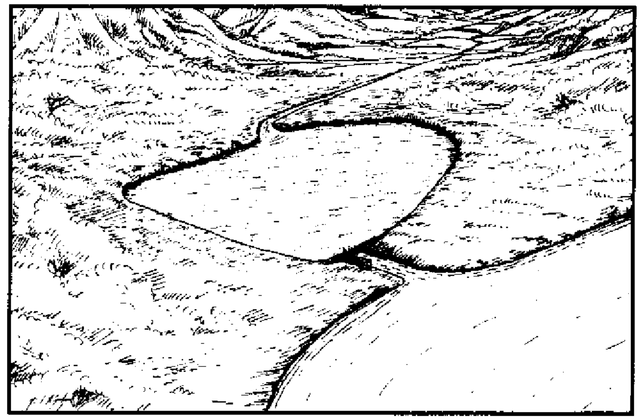
Kāne'ohe

Site: Waikalua Loko
Type of Pond: loko kuapā
Coordinator: Matt Lyum, President
Waikalua Loko Preservation Society
P.O. Box 1917
Kailua, HI 96734
(808) 282-5496
e-mail: mlcinternational@hotmail.com

Site: Mōli'i
Type of Pond: loko kuapā
Coordinator: Barbara Santos
Education Supervisor
Kualoa Ranch
P.O. Box 650
Ka'a'awa, HI 96730
(808) 237-8515 x235

Site: Paepae o He'eia
Type of Pond: loko kuapā
Coordinator: Mahinapoepoe Paishon
47-675 Mele Kula Rd.
Kāne'ohe, HI 96744
(808) 277-2313

Site: Nu'upia Ponds
Type of Ponds: loko pu'uone
U.S. Dept. of the Marine Corps
Nu'upia Ponds Wildlife Management Area
Dr. Diane Drigot, Senior Natural Resources Management Specialist, or
Marine Corps Base Contact Official
Box 63002
MCBH Kāne'ohe, HI 96863-3002
(808) 257-8839



A loko pu'uone is an isolated shore fishpond named for a pu'uone (a sand dune or heap of sand) that holds water in the pond.

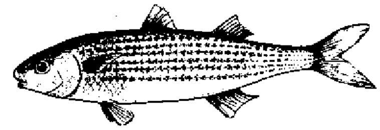
Moloka'i

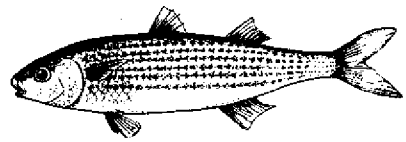
Site: Keawanui
Type of Pond: loko kuapā
Coordinator: Walter Ritte
HC-01 Box 471
Kaunakakai, Moloka'i, 96748
(808) 558-0111
e-mail: rittew@hotmail.com

Site: 'Ualapu'e
Type of Pond: loko kuapā
Coordinator: William "Billy" Kalipi
(808) 553-3590

Maui

Site: Kō'ie'ie
Type of Pond: loko kuapā
Coordinator: Joylynn Oliveira
Hawaiian Cultural Educator
Hawaiian Islands Humpback Whale National Marine Sanctuary
726 S. Kihei Rd.
Kihei, HI 96753
(808) 879-2818
e-mail: joylynn.oliveira@noaa.gov





Hawaiʻi • Hilo

Keaukaha

Site: Waiuli
Type of Pond: loko wai
Coordinator: TBA

Hawaiʻi • Kona

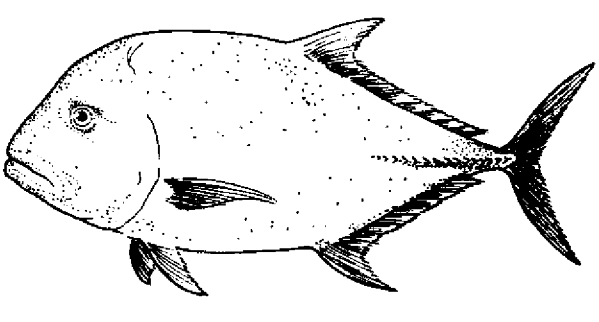
Sites: Kaloko, Aimakapā and Aiʻōpio
Type of Ponds: loko kuapā, loko puʻuone and loko ʻume iki
Coordinator: Dominic Cardea
Interpretive Specialist
Kaloko-Honokōhau National Historical Park
73-4786 Kanalani St., #14
Kailua-Kona, HI 96740
(808) 329-6881 (ext. 209)
e-mail: dominic_cardea@nps.gov

If you are unable to reach the coordinator on your island, please call the Pacific American Foundation on Oʻahu for assistance.

Herb Lee, Project Director
Pacific American Foundation
33 S. King St. Room 205
Honolulu, HI 96813
(808) 533-2836
e-mail: LEE3COM@aol.com

Keep current on fishpond field sites!

www.thepaf.org



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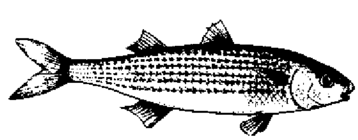

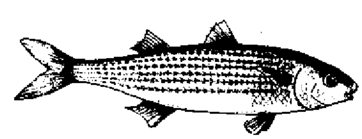

Supplies & Equipment

Aquatic Eco-Systems, Inc. <aes@aquaticeco.com> http://www.aquaticeco.com/ (Source for throw nets, aquaculture supplies and equipment)

Hach Company. <orders@hach.com> www.hach.com/ P.O. Box 389, Loveland, CO 80539 (800) 227-4224 or (970) 669 3050. (Analytical systems and technical support for water quality testing, with solutions for lab, process, and field)

LaMotte Company. <mkt@lamotte.com> www.lamotte.com/ P.O. Box 329, 802 Washington Avenue, Chestertown, MD 21260 (800) 344-3100. (Products for the analysis of water, soil, and air)

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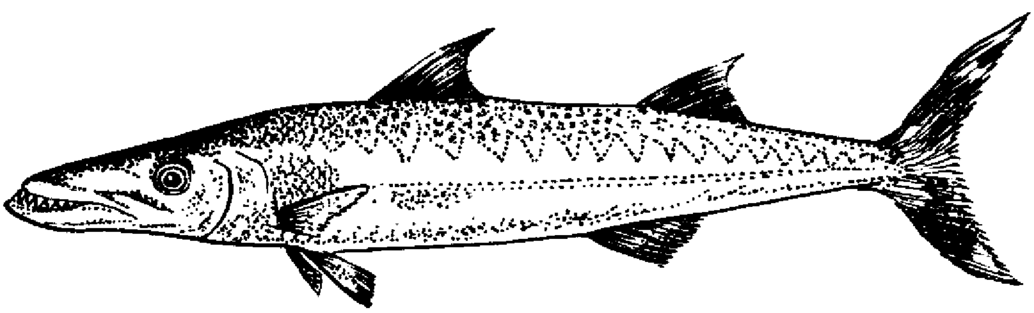
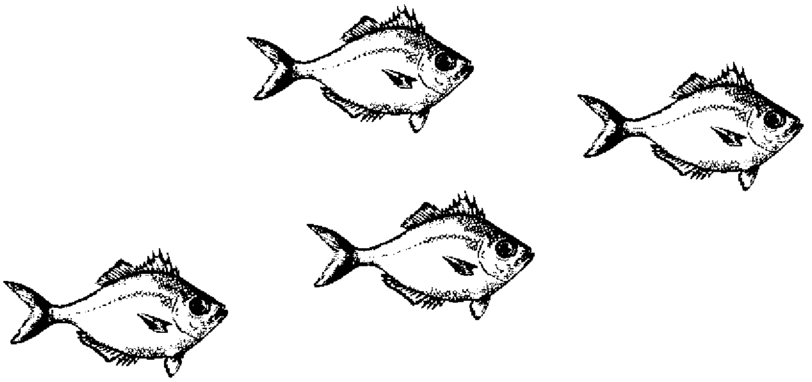
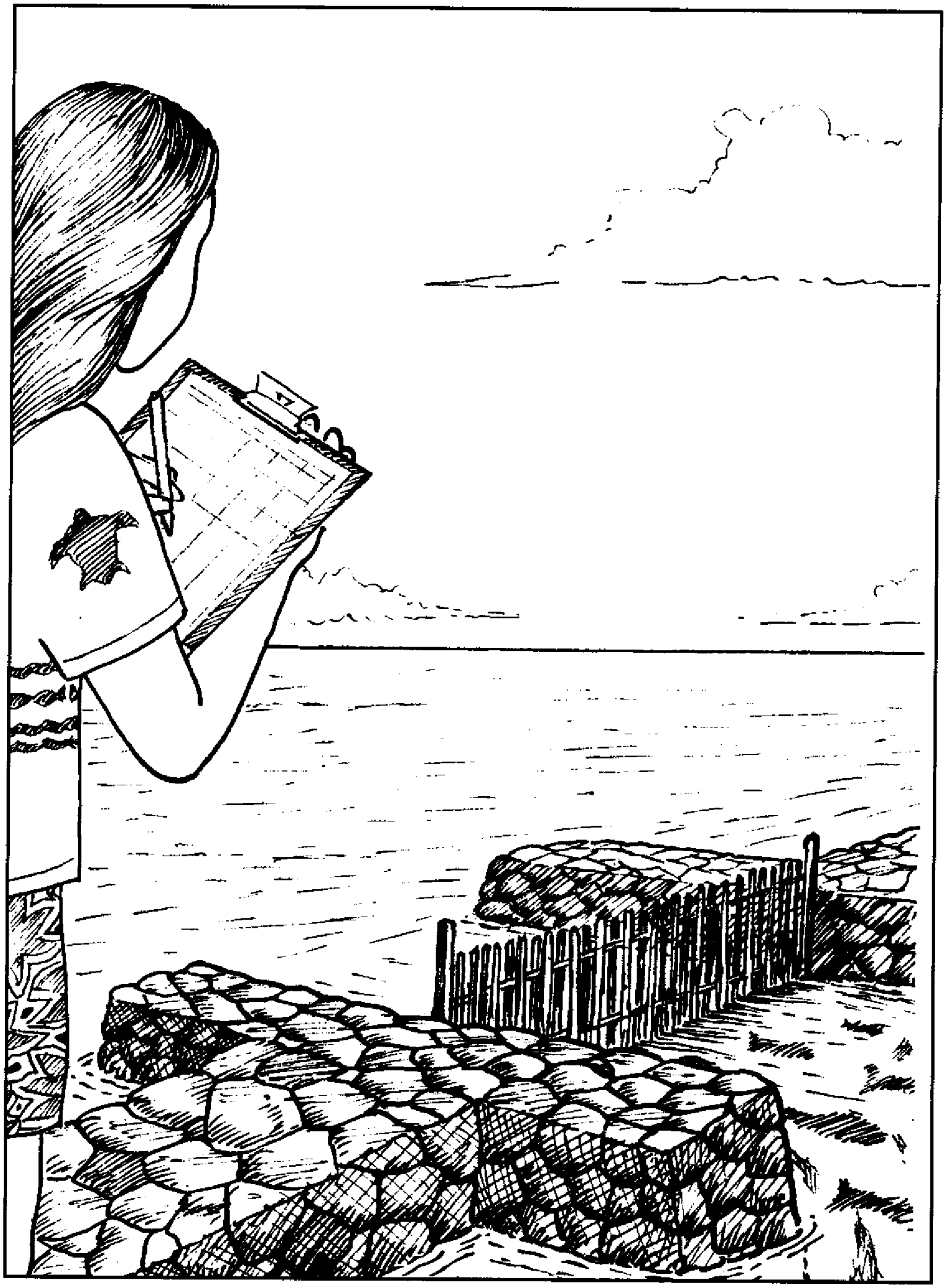




APPENDIX

Creating Rubrics and Portfolios



Creating and Using Rubrics

6

- What is a rubric and how is it used?

Key Concept

A rubric is a guideline for making scoring decisions which may be used to recognize current knowledge and also an evaluation tool to help students achieve higher levels of success in a learning experience.

Activity at a Glance

Students practice constructing a rubric to assess a simple activity, such as clapping hands.

Time

1 class period

Vocabulary

rubric — a guideline for making scoring decisions; a document that clarifies what is expected in a learning experience, and what steps to take to reach higher levels of achievement

performance assessment — a testing method where students are expected to create an answer or product to demonstrate their knowledge and skills

assessment — a measurement of a student's ability or skill

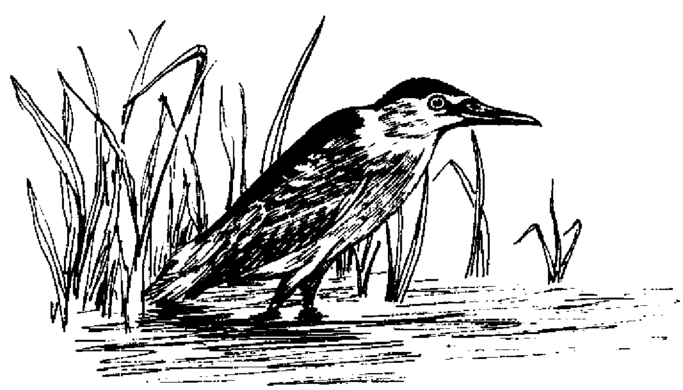
Materials

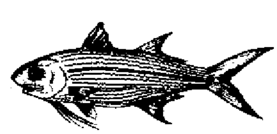
Provided:
- rubric template

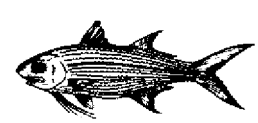
Needed:
- chart paper (or chalkboard/whiteboard)
- markers
- pencils

Advance Preparation

- Make transparencies or make copies of the rubric template.







Background

A rubric is a guideline for making scoring decisions. It is an authentic method to evaluate student performances in various targeted activities. Rubrics allow teacher-student participation in determining the quality of student performance.

"Effective rubrics:

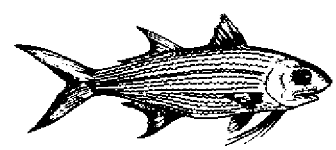
- Reflect the most significant elements related to success in a learning task and
- Enable students and teachers to accurately and consistently identify the level of competency or stage of development.
- Help teachers grade students' work more accurately and fairly.
- Encourage students' self-evaluation and higher expectations.
- Are shared with students prior to beginning the task so they know the characteristics of quality work.
- Provide more information than just a narrow checklist of skills or attributes"

(Kingore, 2000).

An effective rubric is an authentic assessment tool which not only aids the teacher in determining the skills and abilities of a student, but supports and assists the student in improving upon skills that he/she already has.

In order to construct a rubric you must:

- Know what tasks will be evaluated,
- Have a clear scoring criteria, and
- Provide a clear picture of how students will be scored.



If the teacher generates the rubric, time should be allowed for students to react to it and discuss the criteria and scoring. The teacher should facilitate the discussion and make adjustments within reason and discretion. When a rubric is constructed collaboratively with the students, they are allowed to share in the development process. This creates a positive teaching/learning environment where students will feel like they are part of their own learning and assessment. They will not only recognize their current knowledge and skills but they will know how to improve upon them. Use the activity below to demonstrate the construction of a rubric and how it is used.

Teaching Suggestions

1. Select a simple task, such as clapping hands, and establish a scoring or rating scale to fit the rubric template provided.

2. Establish the criteria for assessing the hand clapping and list these on the board or chart paper. Students may come up with criteria such as "volume," "appropriateness," or "creativity."

3. Define each of the criteria and dicuss them with the class.

   a. Volume = the intensity of the sound of the clap that is performed.
   b. Appropriateness = the manner of clapping related to a specific event.
   c. Creativity = how the performer expresses the clap.

4. Give each student a copy of the rubric template provided, or project it on a screen. Explain that this rubric will be used to assess how one claps after a concert performance (such as a popular singing group or band). Have students list the criteria in the left-hand column of the rubric.

5. For each criteria, ask students to come up with descriptions that would describe "kulia" (exceeds standard) to mākaukau ʻole (below standard). Start with kulia and ask students what the criteria would be for an "excellent" performance that exceeds the standard for volume. Write the responses in the box under "kulia." Proceed through the criteria and enter performance expectations for each box in the rubric.

6. Once the criteria and levels of proficiency are established, ask for ten volunteers to clap for the class.

7. Go over the ratings and the criteria and the setting (clapping after a concert performance) before each clapping performance. Ask the students who are not performing to use the rubric to rate each individual performance. Ask one or two students to record the scores and calculate an average.

8. Give certificates or prizes to the winning performance. Then introduce one of the sample rubrics provided in the units in this guide and discuss the criteria with students. Work with students to tailor the rubric to fit their needs.

Adaptations/Extensions

- Instead of clapping hands, students could throw a baseball or demonstrate laughing skills or another area of interest.
- Start with the culminating activity in Unit 1 and have students create a rubric.

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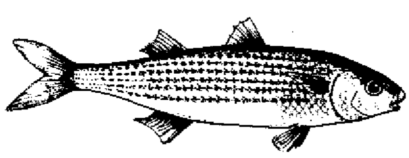

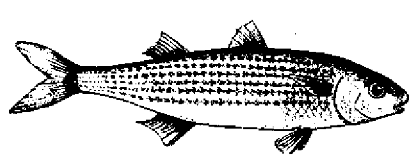

Performance Indicators	Kūlia (Exceeds Standard)	Mākaukau (Meets Standard)	ʻAno Mākaukau (Almost at Standard)	Mākaukau ʻOle (Below Standard)

I NOTICED:

Portfolios

A portfolio is a vehicle for engaging students in the process of self-evaluation and goal-setting. It is a collection of student work that includes pivotal, improved or best pieces as well as teacher and student (and/or parent) commentary. An effective portfolio is student-centered and encourages student responsibility, pride and accountability for learning. It includes goals for students and "allows students to polish and refine what they are learning to do well" (Kingore, 1999). It is also an alternative assessment tool. Like rubrics, it is considered an authentic assessment.

To help with the management of portfolios, include students in the process of selecting and organizing their work. Their portfolios should be the place (portfolio or binder) where students keep specific assignments and information from each unit. Portfolios should include work that is representative and a reflection of the student. The materials collected would also be helpful for the students as they complete the culminating activities in each unit. Have students include lined paper in the portfolios for student and teacher commentaries. Teachers may wish to prepare a checklist of assignments for the students with routine questions like the example below.

- Unit I Lesson 1, Map
- Unit 1 Lesson II, Discussion questions
- Answer these questions:
  - What have you learned in this unit?
  - Were you successful in completing the activities? Explain your answer.
  - What would you have done differently?

Try to have a conference with each student to discuss the comments and to set goals for improving or enhancing student work.

Resources

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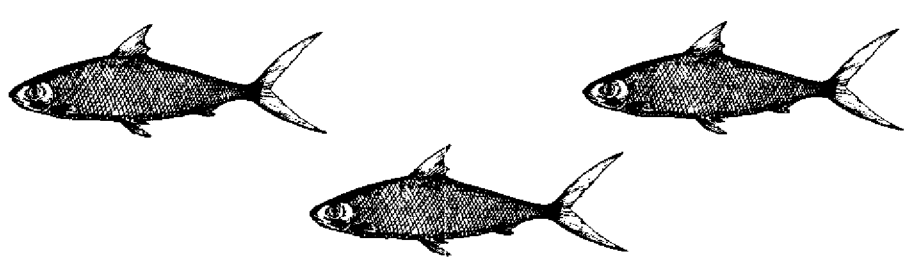


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