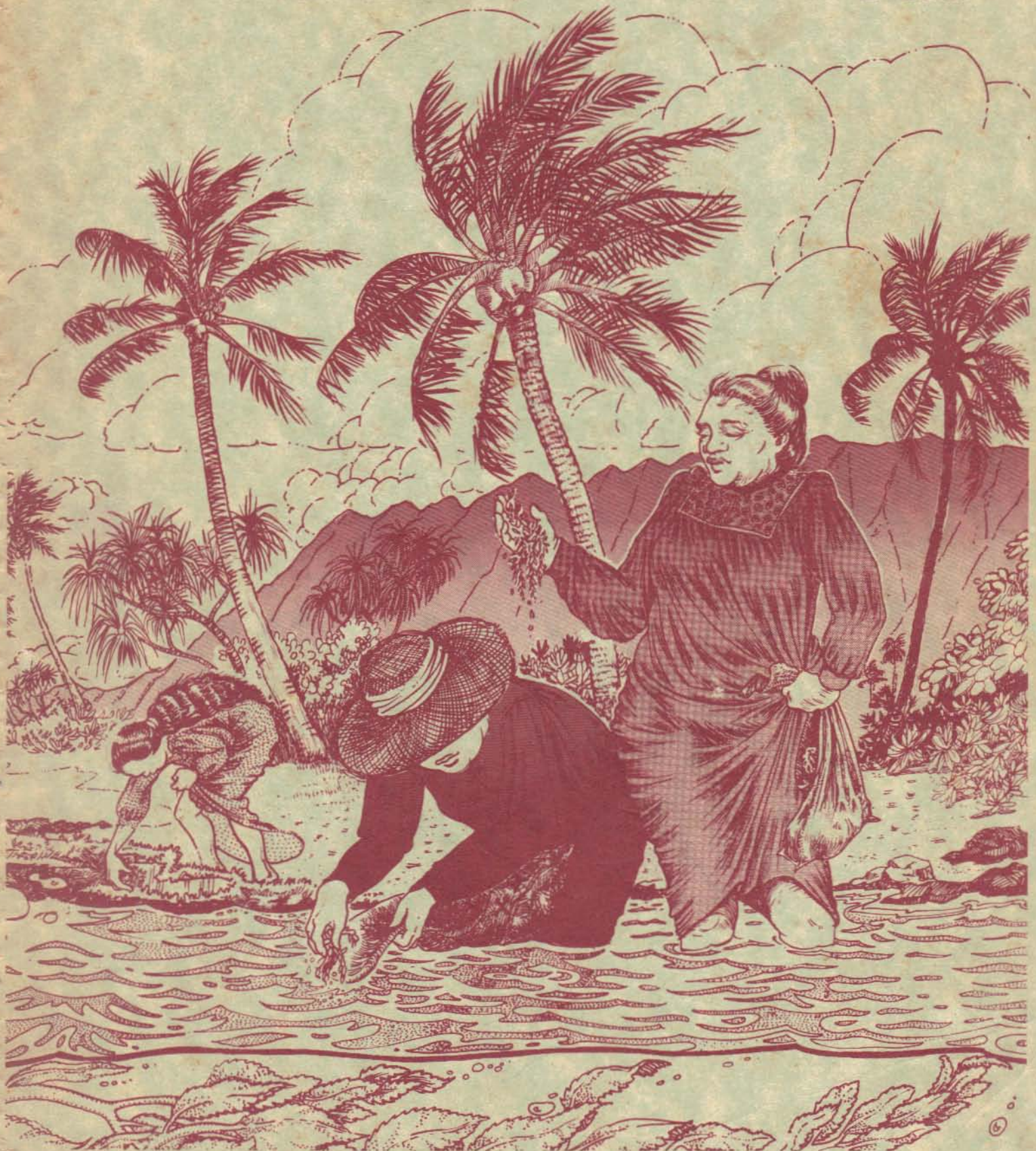
DRAFT

LIMU:

LEARNING ABOUT HAWAI'I'S EDIBLE SEAWEEDS

Instructional Modules for Secondary Teachers

Office of Instructional Services/General Education Branch • Department of Education • State of Hawaii • RS 87-1825 • June 1987



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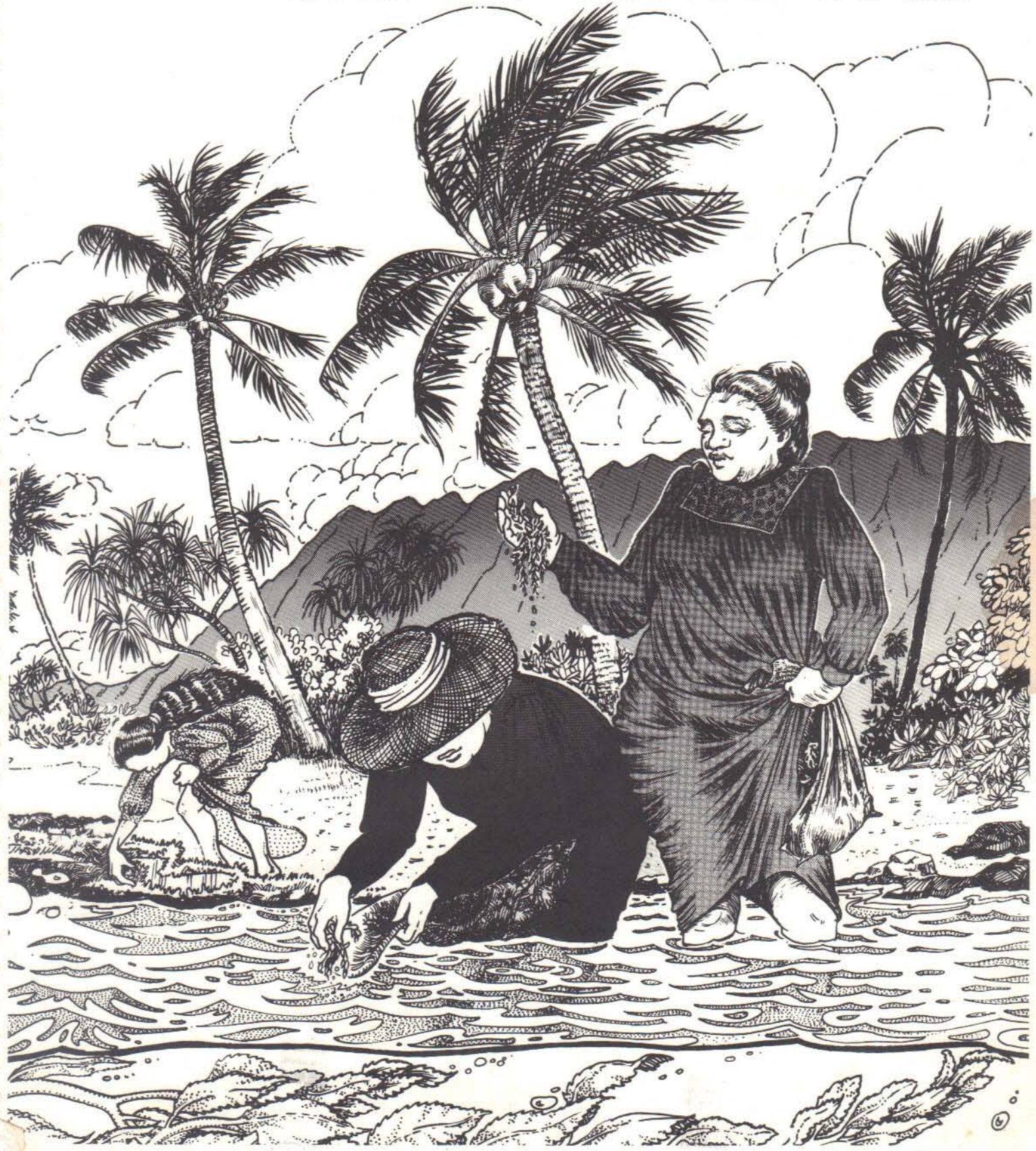

Ku'u wahi i'a 'a'ole ona na'au, a he keu na'e kona ola, a 'ono ke 'ai 'ia, a makemake nui 'ia e nā ali'i a me nā maka'āinana.

Ka limu.

My little fish without entrails, but alive, is very good to eat, and is greatly desired by chiefs and common people.

The seaweed.

from Henry P. Judd, Hawaiian Proverbs and Riddles, p. 75.
Honolulu: Bishop Museum Bulletin 77, 1930.
[diacritical marks added]

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FOREWORD

For many centuries, various types of *limu* have been important parts of the well-rounded diet of the Hawaiian people. Other ethnic groups who have settled in Hawai'i have also incorporated edible seaweeds into their diets and cuisine.

These instructional modules were designed to be used by secondary teachers in all kinds of courses. There are modules that focus on the scientific aspects of the study of *limu* while others deal with seaweed from the Hawaiian language perspective or the economic importance angle. Hawaiian proverbs, wise sayings and legends are presented in relation to the study of *limu*.

Since these modules are being printed in draft form, the Hawaiian Studies program staff earnestly requests that teachers who use the modules provide evaluative comments and suggestions. These may be sent to the Hawaiian Studies program office at the address provided on page i. *Mahalo* to all teachers, *kūpuna*, and students who use these materials to learn about our important natural resource, *limu*, and who provide program staff with critiques of how well or poorly the modules worked.

HOW TO USE THIS BOOK

The topic of *limu*, or edible seaweeds, is one which touches many aspects of life in Hawai'i. From traditional Hawaiian culture to our present multi-cultural society, *limu* is a part of Hawai'i's economy, ecology, diet, imagery, and vocabulary. The purpose of this book is to provide secondary teachers in Hawai'i with background information and a variety of approaches for incorporating lessons about *limu* into their curricula. The modules are designed for use in courses in the natural sciences, social studies, language arts, mathematics, home economics, and environmental studies, as well as Hawaiian studies and Hawaiian language.

Overview of Module Topics

The eight modules in this book look at *limu* from different viewpoints, and stress different skills. The first module, **What's in a Name**, focuses on the sensory experience of *limu* and the process of naming. This leads up to an investigation of the origins and meanings of the scientific and Hawaiian names for some common edible seaweeds found in Hawai'i. The second module, **Mystery Limu**, builds on the familiarity with *limu* characteristics and names to facilitate the use of a field key for accurate identification. In addition, through creating their own simple key, students are introduced to the organizational basis of a classification key.

Students learn about the habitat requirements of different kinds of *limu* in the third module, ***Limu* Habitat Field Study**. They use the information to predict where they might find various *limu* at a particular field site. There they conduct transect studies, check their predictions against their findings, and hypothesize factors which could account for any discrepancies.

Students search Hawaiian legends for clues about role of *limu* in traditional Hawaiian life in the fourth module, ***Limu* in Tradition and Legend**. Other sources are also suggested for student research projects. ***Limu* Metaphors** in *'ōlelo no'eau* (Hawaiian proverbs and wise sayings) are the focus of the fifth module. Students identify attributes of seaweeds that are used to refer to other natural phenomena, social conditions, or personal qualities. Drawing on their own investigations of *limu* characteristics, students are asked to create their own sayings using *limu* metaphors.

The sixth module, **Get *Limu***, invites students out into the community to conduct research on the picking and sale of *limu* in Hawai'i today. Information on amounts harvested and sold over the past decade are provided for comparison of trends. Imported seaweeds and products which include seaweed ingredients are also topics for research in this module. The problem of the declining supply of *limu* such as *ogo* (*Gracilaria* spp. or *Limu manauea)*, and the new state *limu* conservation regulation are addressed in the seventh module, ***Limu* Conservation**.

In the eighth module, ***Limu* for Lunch**, students look at how several different cultures have prepared seaweed dishes. The module culminates with students' trying out various recipes.

Each module is designed to be self-contained. Although they are organized in a progressive order, with each module building to an extent on the previous one, single modules can be selected and taught by themselves. Teachers should review the module to ensure that students are prepared for it through other learning experiences.

Organization of Each Module

Each module specifies the **subject areas** it emphasizes; the **key concepts** it is designed to convey; the student learning **objectives**, and **skills emphasis**. Any special **vocabulary** terms involved in the module are listed, and defined within the module, either in a special vocabulary or glossary, or in the context of a background reading. Any **materials and equipment** required for the module are noted, along with the **time needed** in terms of numbers of class periods. **Cautions** and/or **management suggestions** to the teacher are included in several modules.

The **background** section is written for the teacher, and provides a review of relevant information. Steps for conducting activities are outlined in **procedures**. A few modules also include suggestions for **extensions** or **alternative procedures**. **Resources** for additional information are listed. for teacher or student use. Where needed, **student information** and **instruction sheets** are included, along with **student worksheets**.

Please note: The student materials are provided for the convenience of the teacher. The format of these materials represents only **one** way of approaching each particular investigation. Teachers should feel free to modify and adapt the ideas to fit their situations.

Appendices

In the appendices are materials reprinted or adapted from other sources to supplement various modules. These include:

- the parts of seaweeds, illustrated;
- a Hawaiian song about picking different kinds of *limu*;
- directions for pressing and mounting seaweeds for scientific collections or artistic uses;
- a reading in "conversational" Hawaiian about picking and preparing *Limu kohu (Asparagopsis taxiformis)*;
- a set of pictorial information cards about several *limu*.

Posters

The posters by Sheryl Ives Boynton were designed to illustrate several *limu* **in their particular habitats**. The *limu* pictured are those emphasized in the first three modules in this book. The posters can serve as visual reminders about *limu* characteristics and habitats.

In addition, one poster depicts Hawaiian women picking *limu*. It might be displayed, for instance. while students are engaged in the modules about traditional Hawaiian practices related to *limu* or while they are investigating present day *limu* harvest and sale.

Note: The spelling of all Hawaiian words in this document, including Hawaiian words in titles of organizations and published works, has been standardized to reflect the official modern orthography of the Hawaiian language.

Table of Contents

A. What's in a Name?
Scientific and Hawaiian Binomial Nomenclature Systems

Subject Areas: Life Science
Language Arts
Hawaiian Language
Hawaiian Studies

Key Concept:

Both Hawaiian and scientific names for seaweeds are part of classification systems which reflect different cultures, and help people to identify and communicate about different kinds of seaweed.

Activity Objectives:

Students will be able to demonstrate their understanding of the scientific binomial classification system by "inventing" genus/species names for common objects and seaweeds.
Students will be able to recognize bases for Hawaiian and scientific names of some of Hawai'i's edible seaweeds.
Students will become familiar with Hawaiian and scientific names for some edible seaweeds found in Hawai'i.

Skills Emphasis: sensory awareness
description
vocabulary development

Vocabulary:

algae	binomial nomenclature	genus
seaweed	etymology	species
limu	type specimen	

Materials and Equipment:

several freshly picked samples of various kinds of edible seaweeds (see list page A3)
transparent bowls or pans of salt water for floating seaweed samples
copies of student information sheets, instructions, and worksheets (pages A7-A17)

Time Needed: Two class periods; possible homework assignment [worksheet page A15 or A17].

Cautions/Management Suggestions:

Bowls could be located at various locations in the classroom, to avoid congestion.
In addition, have small samples of each seaweed cleaned of sand, etc. and cut up for tasting.
Paper or cloth towels for drying hands might be a good idea.

Background:

Scientific Binomials

Both Hawaiian and scientific names for seaweeds are **binomials**, or names composed of two parts. Scientific names consist of a generic designation, and a specific descriptive name. The **genus** is capitalized and the **species** name is written with a small letter. For example:

Ulva fasciata *Codium edule*

Sometimes the name of the person(s) who named that seaweed is listed after the binomial, such as:

Ulva fasciata Delile *Codium edule* Silva

The binomials themselves are usually Latin, Greek, or Latinized words, and their use is governed by an international set of rules. The aim of scientific **nomenclature** is to apply one scientific binomial to one species of seaweed, no matter where in the world that seaweed is found. **Type specimens** of each species are stored in museums and universities for reference, along with their descriptions in Latin.

Sometimes the scientific binomials relate to the physical characteristics of the type of seaweed being named. For instance:

Enteromorpha (intestine-form) *prolifera* (bearing offspring)

Other times the genus or species name is a Latinized proper name, or some other, less obvious reference.

Codium reediae (species name after Minnie Reed)
Laurencia dotyi (genus name after Laurence, species name after Maxwell Doty)
Sargassum echinocarpum (genus name related to the Sargasso Sea, in the Atlantic)

It is sometimes possible to guess what some of these words mean, or to trace their origins to Latin or Greek root words. Brief **etymologies** tracing the origins of some scientific names of Hawaiian seaweeds are included for use with this module (see student information sheets, pages A7-A9).

Hawaiian Binomials

Hawaiian names for seaweeds also have two parts. ***Limu*** is a general Hawaiian name for a variety of kinds of plants which grow in or around water, whether fresh or salt. In addition, the term is applied to some mosses, liverworts, lichens, and algae growing in damp places. When referring to a specific type of plant, a second, descriptive word follows. Sometimes the prefix *"lī"* (meaning *limu)* is attached to the descriptive term, as in *"līpoa"* or *"līpe'epe'e."*

Many of these second terms are descriptive of some color, taste, or appearance:

Limu 'ele'ele --'black limu'
Limu alani -- 'bitter limu'
Limu pālahalaha --'spread out limu'
Limu wāwae'iole --'rat's foot limu'

Other specific names refer to where the limu is found, or reflect a cultural meaning or value:

Limu līpoa --'limu gathered from the deep'
Limu līpe'epe'e--'hidden limu'
Limu kohu -- 'supreme limu'
Limu lepe-o-Hina --'the fringe or shawl of Hina'

Sometimes one type of seaweed may be called by different names by people on different islands in Hawai'i. (See Abbott 1984.) Thus the names of Hawaiian *limu* reflect the experience of people using the names to communicate with others close at hand, not necessarily aiming for wider, or universal agreement. A glossary of some of the Hawaiian words used in *limu* names is also included with this module (see student information sheet page A9).
Note: There is no convention regarding capitalization of Hawaiian names for seaweed. In this module, the first word (*Limu*)is capitalized and the second begins with a small letter.

Preparation:

This module is designed to acquaint students with the Hawaiian and scientific names of some of the most commonly used Hawaiian seaweeds. Those which are likely to be found most easily include:

Ulva fasciata	*Limu pālahalaha, pāpahapaha, pakaiea*
Codium edule, C. reediae	*Limu wāwae'iole, 'a'ala, 'a'ala'ula*
Dictyopteris plagiogramma, D. australis	*Limu līpoa*
Sargassum echinocarpum	*Limu kala*
Asparagopsis taxiformis	*Limu kohu, koko, līpehe, līpa'akai*

Try to collect samples of at least the above species, and as many of the following as possible:

Enteromorpha prolifera	*Limu 'ele'ele*
Porphyra species	*Limu pahe'e, lū'au*
Grateloupia filicina	*Limu huluhuluwaena, pakeleawa'a*
Halymenia formosa	*Limu lepe 'ula'ula, lepe-o-Hina*
Gracilaria coronopifolia, G. parvispora	*Limu manauea (G. parvispora is ogo)*
Ahnfeltia concinna	*Limu 'aki'aki*
Laurencia dotyi, L. succisa	*Limu līpe'epe'e*
Laurencia nidifica	*Limu māne'one'o*

[See Module C, pages C11-C14, for tips about sites for collecting the various kinds of seaweeds.]

If you have trouble finding these species of seaweeds:
The student information sheets for this module provide etymologies for the scientific names of the above seaweeds, and a glossary of the Hawaiian words used in the Hawaiian names. A student worksheet (A15) has been developed for use with the five most easily found of these seaweeds, but if your collection differs, use the blank worksheet (A17) and fill in the appropriate names. Consult a dictionary of biological terms for etymologies of the genus and species names of any additional seaweeds, and attach these to the student information sheets.

Procedure:

About Names

1) Discuss with the students why people name things. (For instance, names help us to refer to things out of reach or sight.) What happens when two people have different names for one thing? (In order to communicate effectively, it helps to learn each other's terms.) You can illustrate this by asking someone to bring you an item in the classroom, calling the item by a name you made up for it (or its name in another language). Be careful not to indicate with eyes or gesture which item you mean.

2) Review the meanings of the scientific terms **genus** and **species** (see glossary). Remind students that they may use non-scientific, adjective forms of these words in daily conversation ("generic" and "specific").

3) To reinforce the understanding of these terms and classifications, ask students to work in small groups to invent "genus/species" names for two or more sets of common objects (e.g. shoes, books, types of music). The genus name should be a noun indicating a general category, and the species name can be an adjective that identifies important characteristics of certain items in that category. Ask a representative from each group to present at least one of their sets, and to explain the basis for the names chosen, and which likeness and differences they singled out as most important in their classification systems.

Naming Seaweeds

1) Have a variety of samples of fresh *limu* floating freely in bowls of salt water, one kind per bowl. For ease in referring to each sample, assign numbers to them. Invite students to take turns looking at, feeling, smelling, and tasting each *limu*.

2) Ask students to write a brief description of each *limu*, or to take notes using copies of the ***Limu* Description** worksheet (A13).

3) Based on their sensory impressions, ask students to make up a name for each *limu*. Suggest they use the noun/adjective format as they did above for other objects.

(**Note:** some students may already know common English or Hawaiian names for several kinds of *limu*. Ask them to keep this information to themselves for now, and to think to themselves: "If I were naming this *limu*, what would I call it, based on my observations?")

4) Allow students to work in small groups to compare notes and names, then ask for volunteers from each group to summarize and explain some of the *limu* names each group created. The class may enjoy trying to guess which *limu* are being referred to with the new names.

Finding and Comparing Meanings of Seaweed Names

1) Distribute copies of the **Binomials** worksheet (A15 or A17), along with the student information sheets (A7-A9). Ask students to work with the information sheets to discover the approximate meanings of the Hawaiian and scientific names for seaweeds on the worksheet.

2) Once this is done, ask students to use the meanings of the Hawaiian and scientific names to see if they can match some of them to the seaweeds they observed earlier. Use the numbers for clarity in referring to the classroom seaweed samples.
(**Note:** In some cases the connection is less obvious than others, or may be totally obscure! The Hawaiian and scientific names for each type of seaweed are listed together on the worksheet to make it easier; and "process of elimination" will also allow students to complete the matching.)

3) Ask students to compare the names they gave the seaweeds with the Hawaiian and the scientific names. Which, if any, of the names reflect awareness of similar characteristics? Which, while they might have had some meaning to those who coined the name, don't have an apparent meaning to the students?

Summary Discussion

Ask students to describe some of the similarities and differences between scientific and Hawaiian nomenclature systems. What are some advantages and disadvantages of using each system? Would someone outside of class know what the students were talking about if they used some of the names they invented for seaweeds in class today? Why do scientists use Latin and Greek root words in trying to create a world-wide system?

Vocabulary:

algae, n. plural *(singular:* ***alga)*** a group of plants, varying from one-cell to complex multicellular structures perhaps 150 feet long, containing chlorophyll and other photosynthetic pigments (esp. red and brown), and having no true root, stem, or leaf. Algae are found in any habitat that will support life, especially in water and damp places, and include seaweeds, pond scum, diatoms, etc.

binomial nomenclature (or ***system)*** the scientific system of giving a double name to each plant and animals, consisting of the name of the genus followed by that of the species.

etymology, n. the origin and development of a word; the tracing of a word back as far as possible in its own language and to its source in contemporary or earlier languages.

generic, adj. 1. of, applied to, or referring to a whole kind, or group; inclusive or general. 2. that is not a trademark. 3. of or characteristic of a genus.

genus, n. *(plural:* ***genera, genuses)*** a classification of plants or animals with common distinguishing characteristics: a genus is the main subdivision of a family and is made up of a small group of closely related species or of a single species.

limu, n. a general Hawaiian name for all kinds of plants living under water, both fresh and salt, also algae growing in any damp place in the air, as on the ground, on rocks, and on other plants; also some mosses, liverworts, lichens. Generally applied to edible seaweeds.

seaweed, n. any large alga or algae that grows in the sea.

species, n. *(plural:* ***species)*** the fundamental biological classification, comprising a subdivision of a genus and consisting of a number of plants or animals all of which have a high degree of similarity, can generally interbreed only among themselves, and show persistent differences from members of allied species.

specific, adj. 1. limiting or limited; specifying or specified; precise, definite; explicit. 2. of or constituting a species. 3. peculiar to or characteristic of something. 4. of a special, or particular, sort or kind.

type specimen, n. the single organism designated as the one on which the original description and name of a taxon has been based. Also, type genus or type species.

Resources:

Magruder, William H. and Jeffrey W. Hunt. 1979. Seaweeds of Hawai'i. Honolulu: Oriental Publishing Company. [see esp. pp. 109-110 re nomenclature]

Bryan, E. H., Jr. 1933. Hawaiian Nature Notes. Honolulu Star-Bulletin. [see esp. p. 138 re Hawaiian systematic classification for plants]

For illustrations and descriptions of common edible seaweeds found in Hawai'i, see:

Abbott, Isabella Aiona. 1984. Limu: An Ethnobotanical Study of some Hawaiian Seaweeds. Lāwa'i, Kaua'i: Pacific Tropical Botanical Garden.

Fortner, Heather J. 1978. The Limu Eater: A Cookbook of Hawaiian Seaweed. Honolulu: University of Hawai'i Sea Grant College Program. pp. 5-26 [p. 81-81 re nomenclature].

Brief Etymologies of Selected Scientific Names

Compiled from Henderson's Dictionary of Biological Terms (Ninth edition), Sandra Holmes, ed., New York: Van Nostrand Remhold Company, 1979, and Webster's New World Dictionary of the American Language (Second College Edition). Additional etymologies from Dr. Isabella Abbott, University of Hawai'i Botany Department, and Bill Magruder, Bishop Museum Botany Department.

ahnfeltia	Latinized form of proper name, Ahnfelt, after Swedish botanist.
asparagopsis	from the Greek *asparagos* [asparagus].
australia	from the Latin *australis,* southern, from *auster,* south wind, the south.
codium	from the Greek *codia,* the head.
concinna	from the Latin *concinnus,* skillfully joined, beautiful.
coronopifolia	from the Latin *corona,* crown + *folium,* leaf.
dictyopteris	from the Greek *diktyon,* net + *pteron,* wing.
dotyi	Latinized form of proper name, Doty, after Maxwell Doty, University of Hawai'i Professor of Botany.
echinocarpum	from the Greek *echinos,* sea urchin, prickly + *karpos,* fruit.
edule	edible
enteromorph	from the Greek *enteron,* intestine +*morphe,* form.
fasciata	from the Latin *fascia,* a band.
filicina	from the Latin *filix,* fern-like.
formosa	from the Latin *formos,* graceful, beautiful.
gracilaria	from the Latin *gracilis,* scanty, slender, slim.
grateloupia	Latinized form of proper name, Grateloup.
halymenia	from the Greek *halys,* a chain, bond + *meme,* moon.
laurencia	Latinized form of proper name, Laurence.
nidifica	from the Latin *nidus,* nest + *facere,* to make.
parvispora	from the Latin *parvi,* small + *spora,* spore.
plagiogramme	from the Greek *plagios,* oblique, from *pelagos,* the sea; + *gramme,* line.
porphyra	from the Greek, *porphyra,* purple.
prolifera	from the Latin *proles,* offspring +*ferre,* to bear.
reediae	Latinized form of proper name, Reed, after Miss Minnie Reed, a teacher at Kamehameha Schools around 1900. Miss Reed was one of the first to try to match Hawaiian names for *limu* with their scientific names.

sargassum	Modern Latin, from the Portuguese *sargaço,* from *sarga,* kind of grape. The Sargasso Sea in the north Atlantic Ocean is famous for all its sargassum.
succisa	from the Latin *succiss,* cut, bitten off, trimmed, lopped off.
taxiformis	from the Greek *taxis,* arrangement, division + the Latin *formis,* form.
ulva	Linnaean name for a marsh plant. (Linnaeus was the Swedish botanist who developed the genus/species system for classification of plants and animals.)

Glossary of Some Hawaiian Words Used in Names of *Limu*

Compiled from Pukui and Elbert, Hawaiian-English Dictionary, and Dr. Isabella Abbott's Limu.

'a'ala	fragrant, sweet-smelling; ***'a'ala'ula*** means red fragrance.
'aki'aki	to nibble.
'ele'ele	black, dark.
Hina	one of the most important Hawaiian goddesses.
huluhuluwaena	pubic hair.
kala	to loosen, forgive, substitute for.
kohu	supreme.
koko	dark red.
lepe	hem, fringe, or shawl.
līpa'akai	*lī* refers to limu, + *pa'akai* means salt, salty.
līpe'epe'e	*lī* refers to limu, + *pe'e,* to hide.
līpehe	*lī* refers to limu; light-colored.
līpoa	*lī* refers to limu; gathered from the deep.
lū'au	young taro tops, especially cooked.
māne'one'o	itchy, smarting, ticklish.
manauea	erect branches.
pahe'e	slippery, smooth, soft, satiny; to slide, skip, skid.
pakaiea	ruffled, heart-shaped leaves.
pakeleawa'a	slipping from *(pakele)* the canoe *(wa'a).*
pālahalaha	spread out, extended, flattened, wide, broad, broadened.
pāpahapaha	uncooked young taro leaves.
'ula'ula	red.
wāwae'iole	rat's foot.

Student Instructions

Investigating and Naming Sample Seaweeds

1. Take turns observing the samples of seaweed displayed around the room. Use the ***Limu* Description** worksheet to record your findings.

   For each seaweed:

   a. Write down the **number** of the sample.
   b. **Look at** the seaweed and write down the **colors** you see in it.
   c. Look at the **shape** of the seaweed overall, and the shape of its parts. Write down a few words to describe these shapes.
   d. **Feel** the seaweed and write down one or two words to describe how its **texture**.
   e. **Smell** the seaweed and write down one or two words to describe its smell.
   f. **Taste** the sample of cleaned seaweed, and write down one or two words to describe the taste.

2. If you were naming this seaweed, based on your observations, what would you name it? Invent a two-word name for each seaweed. Use a **noun**, and an **adjective** which describes the most striking quality of the seaweed. Write the name you give each seaweed in the box under its number and description.

. . . . . .

Student Instructions

Finding and Comparing Meanings of Seaweed Names

1. Find meanings for the words which make up the Hawaiian and scientific names of the seaweeds on the worksheet, **Scientific and Hawaiian Binomials for Seaweeds.**

   The first name in each box is the scientific name, and the second name is the Hawaiian name for the same seaweed.

   You can find origins or meanings for the words which make up these names in these word lists:

   - **Brief Etymologies of Selected Scientific Names**
   - **Glossary of Some Hawaiian Words Used in Names of *Limu***

   Look up each word on the appropriate list, and write down its etymology (origin) or meaning on the worksheet, on the line under the name where the word appears.

2. Now that you know some of the meanings and origins of the Hawaiian and scientific names, see if you can use those ideas as clues to match the name sets with the seaweeds you investigated in class. Refer back to your ***Limu* Description** worksheets.

   When you find a sample described in your notes that seems to match a scientific and Hawaiian name set, write the number of the sample and the name you gave the seaweed in the box.

3. Compare the names you gave the different seaweeds with the Hawaiian and scientific names. Do the names in any set refer to the same qualities, or different qualities?

Limu Description Worksheet

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Number: ____
Color(s):

Shape (of various parts):

Texture:

Smell:

Taste:

I would name this:

Scientific and Hawaiian Binomials for Seaweeds

Ulva fasciata

_____

Limu pālahalaha, pāpahapaha, pakaiea

_____

Number: ____

Our Name for it:

_____

Codium edule, C. reediae

_____

Limu wāwae'iole, 'a'ala, 'a'ala'ula

_____

Number: ____

Our Name for it:

_____

Dictyopteris plagiogramma, D. australis

_____

Limu līpoa

_____

Number: ____

Our Name for it:

_____

Sargassum echinocarpum

_____

Limu kala

_____

Number: ____

Our Name for it:

_____

Asparagopsis taxiformis

_____

Limu kohu, koko, līpehe, līpa'akai

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific and Hawaiian Binomials for Seaweeds

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

Scientific Name: _____

_____

Hawaiian Name: _____

_____

Number: ____

Our Name for it:

_____

B. Mystery Limu: Using Field Keys for Identification

Subject Area: Life Science
Biology
Botany
Language Arts (vocabulary development)

Key Concepts:

Classification and field identification keys are tools for organizing information about related items with distinctive characteristics, and for identifying the items using those characteristics.

Field identification keys can be useful tools for identifying genera of seaweeds.

Activity Objectives:

Students will be able to develop their own simple classification key.
Students will understand the basic organization of a dichotomous key.
Students will be able to use a field key to identify seaweeds.

Skills Emphasis:

observing and recording characteristics of seaweeds
developing criteria for a simple dichotomous key
using glossary and dictionary
developing and using scientific vocabulary
estimating thickness in millimeters
conducting simple scientific experiments
interpreting results of experiments
selecting descriptions from field key to match observations

Vocabulary:

blade	calcareous	pigment	reproductory lumps
cell	dichotomous	pinnate	thallus
crust	filament	stipe	unilateral
	holdfast	stony	

(See pp. B7-8 of "An Expanded Field Key to Common Seaweeds" in the Field Keys to Common Hawaiian Marine Animals and Plants for most of these terms. For additional terms, helpful in using both field keys, see the glossary of the Expanded Field Key, pp. B43-B45. See also Appendix 1 in this book for the names of parts of seaweeds.)

Time Needed: Two class periods.

Management Suggestions:

This module is especially appropriate for small groups of students working together. Groups of three to four students can first create a simple classification key. They can share a field key, and divide the responsibilities for following the steps in the key, looking up unfamiliar terms, and examining the seaweeds. Groups can also work together to follow instructions for preparing slides, and testing for color categories and calcium in the seaweeds.

Resources Needed:

For each student small group:

One copy of one or both **Field Keys to Common Seaweeds**, including glossary, from Field Keys to Common Hawaiian Marine Animals and Plants, Hawai'i Department of Education publication RS 83-4549. (Pages A3-A36 and/or pages B1-B45.)

Materials and Equipment:

For each student:

a copy of the student instructions, **Creating a Dichotomous Key** and **Using a Field Key**

optional: copy of **Special Methods and Cautions**, page B4.

For each student small group:

five or more samples of different local seaweed species, freshly picked *

coins (as aids for estimating thickness in milimeters--see p. B7 of Field Keys)

new single-edged stainless steel razor blade

glass slides and cover slips

microscope

3 percent normal hydrochloric acid (HCL)[or vinegar]

eye dropper

fresh water

alcohol

water containers

means of heating water to 65 degrees Celsius

Celsius thermometer

*Include, if possible, some seaweeds **not** used in Module A, especially calcareous genera.

Background:

Benefits of Using a Field Identification Key

It is possible to identify many of the large species of seaweeds found in Hawai'i by using a pictorial guide (such as Magruder and Hunt's Seaweeds of Hawai'i). However, seaweeds of the same species can vary greatly in size, color and shape depending on environmental conditions. In addition, the appearance of some seaweeds differs greatly during different phases of reproduction. Positive identification of seaweeds usually requires microscopic examination of their particular features, and familiarity with the terms to describe them. Learning to use a field key, students can develop careful observation skills, and familiarity with scientific terms for various significant seaweed features. They can learn some simple laboratory techniques to help in identification. Understanding how to use a field key can also carry over to other biological studies.

Differences between the Two Field Keys to Common Seaweeds

There are two field keys to common seaweeds in Field Keys to Common Hawaiian Marine Animals and Plants. The first, "An Abbreviated Field Key," is the shorter, and may at first glance appear simpler to use. Its use, however, requires that you and your students know at the start whether the seaweeds you are going to identify are considered green, brown, red, or blue-green algae. Seaweeds are classified in these divisions according to their predominant photosynthetic pigments. There are a few simple biochemical tests to help distinguish between seaweeds with different pigments. See the section on **Special Methods**, page B4.

The second, "An Expanded Field Key" is a true **dichotomous key**--that is, a key presenting a series of choices between **two** pathways. Following one of the "branchings" at each step can lead to the generic name for the seaweed. The determination of green, brown, red, or blue-green comes at a later stage in this investigation. The Expanded Key has been developed with a "skeleton" of the key for practice, and it is recommended that the teacher, at least, work through the skeleton before presenting the class with this module.

Overview of Module

The first part of this module is adapted from a lesson plan devised the the U. S. Forest Service for their "Investigating Your Environment" workshops. Students are asked to create a simple dichotomous key. Through this process students may come to recognize the value of classification systems based on observable characteristics. After the experience of creating their own keys, students should be better equipped to understand the organization of the field keys provided for them.

In the second part of the module, students will actually use one of the Field Keys to discover the generic name for one or more seaweeds. One hurdle in using either Field Key may be the vocabulary. At first, students may need to refer often to the glossary which follows the Expanded Key, and perhaps a regular dictionary as well, in order to interpret and understand the descriptions in the Keys. Continued practice will lead to greater facility in using the scientific vocabulary. The terms themselves are useful in focusing attention on the distinguishing features of the seaweeds.

Special Methods and Cautions:

1. To distinguish between red and brown seaweeds:

Immerse seaweeds in hot water of 65° Celcius for 4 minutes, and watch to see whether they turn green. Most brown seaweeds will turn green in 2 minutes, but most red seaweeds will not turn green in 4 minutes. The hot water will dissociate the brown pigments which mask the chlorophyll, thereby allowing the green color to show. But the pigments of most red algae do not dissociate in this temperature of water.

Note: Some red seaweeds **do** turn green with this treatment (such as species of *Gracilaria [ogo, limu manauea]*), but they are generally distinctively red in color to start with, especially at the base (if they are not bleached out). Dr. William Magruder, botanist at the Bishop Museum and co-author of Seaweeds of Hawai'i, recommends that the teacher wanting to use the hot water method try it out ahead of time with the types of seaweeds to be tested in class.

2. To determine whether a seaweed is calcareous:

Place a few drops of a dilute acid such as hydrochloric acid (3 normal HCL) on a clean surface such as a glass slide. Crush a small piece of the seaweed and place it in the HCL. If the piece bubbles rapidly, it is calcareous. The bubbling is carbon dioxide (CO_2), indicating the presence of calcium carbonate in the seaweed.

Note: Dr. Isabella Abbott of the University of Hawai'i Botany Department and author of Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds, suggests that vinegar may work as well as hydrochloric acid, although it might take longer. She also points out that this test is not foolproof, due to the possible presence of epiphytes on the seaweeds. Dr. Abbott suggests that students try to cut the seaweed with a razor blade. If they can't cut it (as would be the case with coralline algae), it's calcareous!

3. To prepare cross sections of seaweed for microscopic viewing:

Place a small piece of seaweed directly on a glass slide. Place your index finger on the seaweed at a 45° angle to the slide. As you cut thin cross-sections of the seaweed with the razor-blade, you will gradually lower your index finger--this pushes the seaweed forward toward the blade. Make several slices. Add a few drops of water to float the cross-sections apart. If there are too many, or some aren't as transparent as others, remove the extra cross-sections. Place a cover-slip over the slide and move it up and down gently--this will further separate the cross-sections for clearer viewing under the microscope.

Procedure:

Creating a Dichotomous Key

1. Divide students into small groups of three to four. Give each group a set of five (or more) different seaweeds,* and copies of the student instructions for **Creating a Dichotomous Key**.

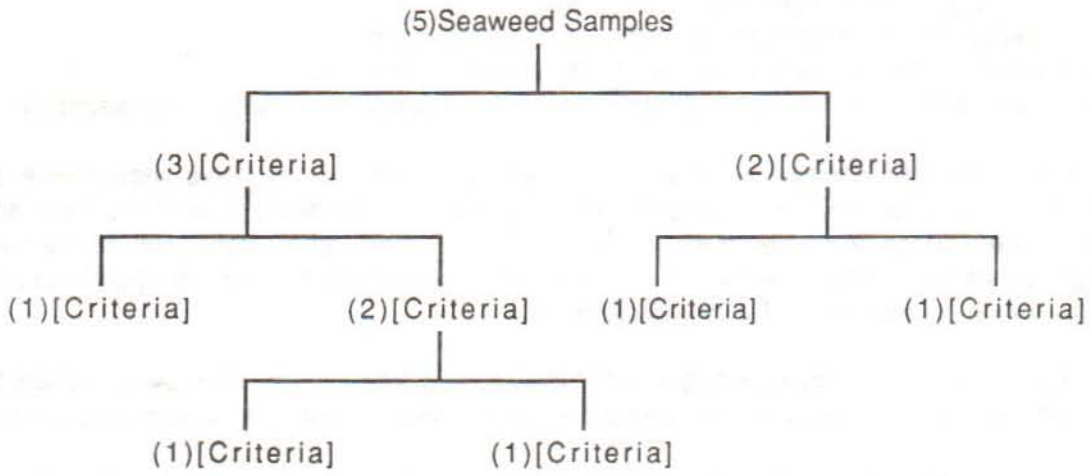
2. Within each group, ask students to look closely at each seaweed sample, and list its observable characteristics. One way to accomplish this would be for each student to be responsible for listing the characteristics of one or two seaweeds, then sharing his or her list with the rest of the group.

3. Now ask each group to divide their seaweed samples into two sets, based on what they see as major similarities and differences in the characteristics of the seaweeds. Ask them to write down the criteria, or reason for their dividing the seaweeds the way they do. (For instance, some criteria might be size, color, or texture.)

4. Ask a representative from each group to tell the criteria they used to divide their seaweeds. List all the criteria on the blackboard.

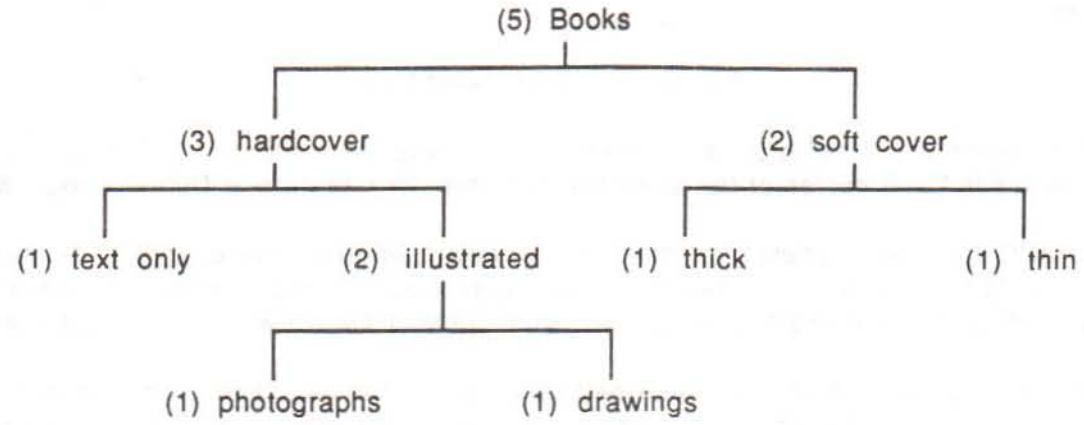
5. Ask students to use their own criteria now to construct a classification key for their seaweeds. Starting with the two sets they have, they can divide each set into two more sets, based on further similarities and differences in seaweed characteristics. Ask students to continue dividing their sets until they have only one seaweed sample in each set. When they have finished dividing up the seaweed samples, students can record their key on a large sheet of paper, specifying the criteria at each branching point.

To illustrate the process, draw a key such as the following on the board as you give the instructions:



Summarize by pointing out that student groups have created **dichotomous keys**, if their keys show a **branching** pattern where differences are used to divide sets **in two**. (Note: Some classification keys are not dichotomous, such as the Abbreviated Key to Common Seaweeds.)

*The process of creating a dichotomous key may also be done with items other than seaweed. It may be helpful to demonstrate the process, for instance, using objects commonly found in the classroom, such as types of books, paper, pens, or footwear. Just be sure to select a set of objects which have observable similarities and differences, e.g. size, color, pattern. Remind students to use **characteristics** of items, rather than **names**, for their criteria. See the following sample.



Using a Field Key

1. The student instructions, **Using a Field Key**, will work with either one of the keys to common seaweeds in Field Keys To Common Hawaiian Marine Animals and Plants. Choose one of the keys, and walk through the steps with the class, "keying out" a sample seaweed. [It might be convenient to use the genus illustrated in the instructions for using the Abbreviated Key, *Ulva (Limu pālahalaha* or sea lettuce).]

2. Demonstrate the special methods, described above, for distinguishing colors, determining whether a seaweed is calcareous, and preparing a cross-section for microscopic viewing. Emphasize caution in using razor blades, hot water, slides, and hydrochloric acid.

3. Allow students to work in small groups, each student taking a role such as:

- reading aloud the descriptions in the key
- looking up unfamiliar words in the glossary or dictionary
- examining the seaweeds for the characteristics mentioned
- following the special procedures for testing seaweeds or viewing cross-sections.

4. To keep track of the choices made as they work through the key, students should write down the numbers of the descriptions they choose for each seaweed. **Optional:** one student in each group could record the choices on a large sheet of paper, using a branching diagram such as the ones made in the first part of this module. Also see examples on the next page. These diagrams can reinforce visually the basic organization of a classification key.

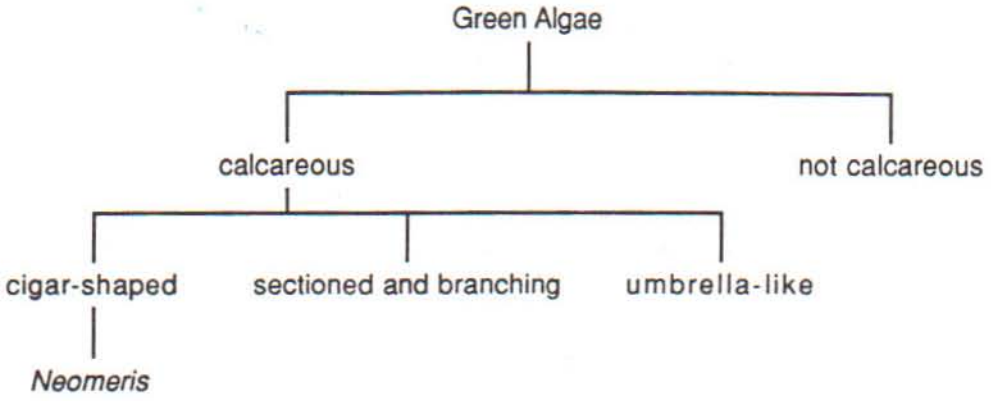
5. Give each small group one or two more seaweeds to key out on their own. When they are finished, ask representatives to report groups' findings, sharing their branching diagrams.

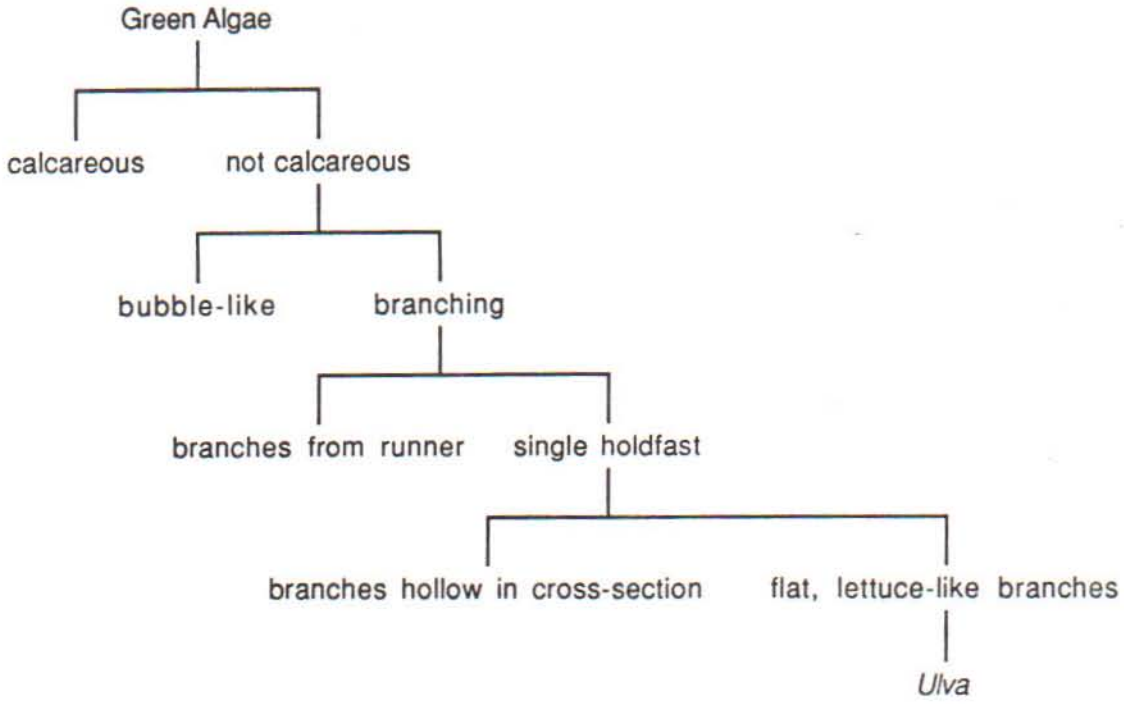
6. **Summary Discussion:** Ask students to compile a list of the features that they found most useful in distinguishing between different genera of seaweeds.

Alternative Procedure: The authors of the "Seaweed Identification" lesson in Chapter 3 of High School Marine Science Studies (University of Hawai'i Curriculum Research Development Group 1982) suggest that students learn to use a key by looking first at the drawings, to find the one that looks most like their seaweed. Students then **work backwards** through the key by number. If each description matches their seaweed, then they have correctly identified their seaweed.

Example of Branching Diagrams Used to Record Choices in a Field Key:

Sample specimens keyed out using the Abbreviated Key, page A-5:





Student Instructions
Creating a Dichotomous Key

1. Your group has been given samples of several different kinds of seaweeds.

   •Look at each of them carefully, observing the characteristics of each one.

   •In particular, look for characteristics which are alike, or different among the seaweeds.

   •List the characteristics for each seaweed on a separate piece of paper.

2. Now divide your seaweed samples into **two sets**, based on what you see as major similarities and differences in the characteristics of the seaweeds.

   •Write down the criteria, or reason for your dividing the seaweeds the way you do. For instance, criteria for one division might be that one group of seaweeds have a certain characteristic, and the seaweeds in the other group don't have that characteristic.

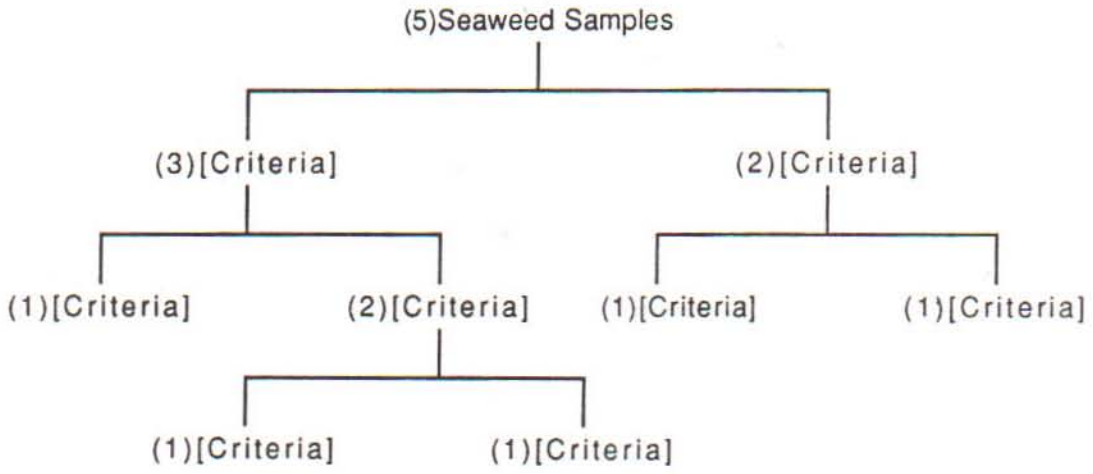
   •Be prepared to tell the rest of the class what criteria your group used.

3. Now you can begin to contruct a classification key for the seaweeds, using your own criteria.

   •Starting with the two sets you have, divide each set into two more sets, again based on similarities and differences in seaweed characteristics.

   •Continue dividing your sets until you have only one seaweed sample in each set. Each time you divide the sets, record your criteria for doing so.

   •When you have finished dividing up the seaweed samples, record your key on a large sheet of paper. Write the criteria you used at each branching point.



Student Instructions
Using a Field Key

1. Look at the Field Key you'll be using. The Key is composed of several short descriptions, with numbers before and after them. These numbers are directions for finding your way through the Key.

   • Look at the numbers to the left of the descriptions. Any descriptions having the same first number are a set.

   • Note that each description except the first set has two numbers to its left. The second number is in parentheses ( ), and refers to the number of the previous description that led to this one.

   • Each description also has one number, after a series of dots, on the right. When you read a number after a description, you should go to the description having that number on its left.

Example:

18 (17) - Stony, i.e., calicified and thus hard	20
18 (17) - Fleshy, i.e., not calcified and thus soft	19

The number of this description set is 18. The previous description (which gave the direction to read this one next) was 17. The choice here is between stoniness or fleshiness of the seaweed sample. If it's stony/hard, you should read 20 next; if it's fleshy/soft, you should read 19 next.

2. Examine the seaweed sample. Note its color, size, texture, and any other outstanding features.

3. Read the first set of descriptions in the field key. Look up any unfamiliar words in the glossary, or in a dictionary. Reread the descriptions and decide which one fits the seaweed you have.

4. Find the number at the end of the description that fits your seaweed. Write down the number and go to the set of descriptions with that number.

5. Repeat steps 3 and 4 until the description you choose refers you to a seaweed drawing (such as "figure 1") and a scientific name.

6. Find the seaweed drawing and compare it with your seaweed. If the drawing is similar to your seaweed, write down the name of that seaweed.

For your convenience:

A few additional terms not defined in glossary of Field Keys: (from Webster's New World Dictionary of the American Language, Second College Edition 1980)

apex, n. *(plural: apexes, apices)* the pointed end, tip. *apical, adj.*

parenchyma, n. a soft tissue made up of thin-walled, undifferentiated living cells with air spaces between them constituting the chief substance of plant leaves and roots, the pulp of fruits, the central portion of stems, etc. *parenchymatous, adj.*

C. Limu Habitat Field Study: Zonation and Distribution

Subject Areas: Life Science
Biology
Botany
Environmental Science
Math
Language Arts

Key Concept:

A number of environmental factors influence *limu* habitat, including availability of light and nutrients; water depth, transparency, temperature and movement; salinity; type of substratum; tidal fluctuation; shoreline topography and wave exposure; grazing by fishes and picking by humans.

Activity Objectives:

Field trip preparation

Students will be able to read and interpret written information concerning *limu* habitats.
Students will be able to predict zones and habitats where particular *limu* could be found on a field trip to a coastal site.

Field trip

Students will follow appropriate procedures for coastal field trip safety.
Students will be able to locate and identify *limu* species along a transect line.
Students will be able to estimate percentage of cover of various *limu* within a quadrat.
Students will be able to identify and measure environmental factors influencing *limu* habitat.

Post-field trip

Students will be able to compare *limu* distribution along different transects, and percentage of *limu* cover in different quadrats.
Students will be able to draw inferences about existence of *limu* habitats at the field site.
Students will be able to hypothesize reasons for any discrepancies between their predictions and their findings.

Skills Emphasis:

reading and using scientific material to make predictions
identifying *limu* in the field
estimating percentage of cover of *limu*
identifying and measuring or estimating environmental factors
comparing data
hypothesizing causes
generalizing from empirical data

Time Needed:

Field trip preparation: one or two class periods including equipment preparation
Field trip: three hours including summary discussion, plus travel time to and from site.

Vocabulary:

brackish	photosynthesis	shoreline topography	tidal fluctuation
coralline algae	quadrat	siltation	transect
habitat	reef crest	splash zone	transparency
intertidal zone	respiration	substrate	turbidity
nutrients	salinity	subtidal zone	vertical zonation
			zero tide level

Materials and Equipment:

For each student (for in-class field trip preparation):
- **Prediction Worksheet** and **Student Instructions** (pages C15-C17)
- ***Limu* Habitat Notes** and **Notes on *Limu* Distribution** (pages C19-C23)
- **Transect Study Procedures** (pages C25-C27)

For each student team (for field trip):
- Pencil and clipboard with **Field Study Worksheets** (one worksheet per quadrat), **Student Instructions** (pages C29-C31)
- Transect line marked off at meter intervals with waterproof ink
- Several plastic bags with blank labels for *limu* specimens
- Knife for cutting *limu*
- Quarter meter quadrat (see below for instructions for making quadrats)
- Plastic ruler (or with waterproof ink, mark off centimeters along one edge of quadrat)
- *Thermometer
- *Hydrometer (optional)
- *Water test kits for measuring dissolved oxygen, nitrogen, phosphorus (optional)
- **Transect Profile Worksheet** (page C33--optional)

*These tools, along with instructions for use, are available through the DOE Marine Education Resource Center. Arrangements can be made through District Science Education Specialists to borrow them.

Copies of one of the field keys to common seaweeds from Field Keys to Common Hawaiian Marine Animals and Plants, Hawai'i Department of Education publication RS 83-4549, if needed by student teams for field identification of *limu.*

An easel, large pad of newsprint, and large felt-tip pens for summary discussion.

Management Suggestions:

Review safety procedures for coastal site field trips. [See the DOE Coastal Field Sites guide, pp. A1 - A30 for important water safety guidelines, first aid and emergency techniques, descriptions of dangerous marine organisms, and guidelines for collecting specimens.] Establish and discuss with students rules of conduct for this field trip.

Background:

In marine environments in Hawai'i, there are a number of factors which contribute to or limit *limu* **habitats**, that is, places which provide what these plants need in order to live. Some of the basic life supporting factors are the same for *limu* as for land plants: **light, oxygen** and **carbon dioxide,** and **nutrients.** Because of the marine environments in which *limu* grow, these basic needs are in turn influenced by other factors, including **water depth, temperature, transparency** or **turbidity** , degree of **salinity** (salt concentration), degree of **water movement**, and exposure to air by **tidal fluctuation**. Also important are **shoreline topography** and type of **substratum** (bottom surface) to which the *limu* attach. The size of fleshy *limu* is often impacted by **grazing fishes**, and **overpicking** or **incorrect picking** by humans can severely reduce *limu* populations.

Light

Like other plants, *limu* make their own food through **photosynthesis**, converting light energy into energy-rich chemicals. Therefore, *limu* need sunlight. The amount of sunlight that can reach *limu* is affected by **water depth**, and **transparency** or **turbidity**--that is, whether the water is clear, or muddied and stirred up with particles. Different *limu* seem to have differing light requirements, as some are found growing in dark cracks and crevices, or under other *limu*.

Water temperature, oxygen and carbon dioxide

Limu use **carbon dioxide** and produce **oxygen** during the day, through the process of photosynthesis. At night, *limu* use oxygen and produce carbon dioxide through **respiration**. In tide pools, the oxygen produced by the seaweed saturates the water during the day, but is lost as the water heats up. When photosynthesis stops at night, respiration by *limu* and marine animals in the tidepools uses up the remaining dissolved oxygen, reducing its concentration to very low levels. This limits growth, particularly of marine animals.

Nutrients

Nitrogen and phosphorus are two of the most important **nutrients** (food substances)for *limu*. These are available in varying amounts in the water surrounding the *limu*. The presence of nutrients is impacted by **water movement**--waves and currents carrying away waste materials and bringing fresh supplies of nutrients into the area. **Fresh water runoff** and streams carry nutrients (including fertilizers) from the land into the sea. The discharge of sewage (including human waste) is another source of nutrients for marine life.

Note: Land development or deforestation can affect *limu* habitat. Streams and runoff can bring to the shore areas loads of **silt** (fine grained soil carried and laid down by moving water). **Siltation** of shoreline areas can block sunlight from *limu*, or cover the bottom with a soft and shifting surface unsuitable for *limu* attachment.

Substratum

Most *limu* are attached by their holdfasts to hard surfaces rather than soft and shifting surfaces such as sand, mud or gravel. Rocky shorelines, reef flats and tidepools provide excellent **substrata** (plural of substratum) for *limu* attachment. Concrete pilings, lava boulders and other hard objects also provide *limu* attachment sites.

Salinity

Different species of *limu* vary in their ablity to tolerate degrees and changes in salinity. Some species, such as *limu 'ele'ele,* thrive in **brackish** (mixed fresh and salt) water, such as that found at the mouths of streams or near springs at the edge of the sea. These areas also receive the benefit of nutrients carried by the streams from upland.

Changes in salinity are especially found in tide pools. Here the water may be subject to evaporation, resulting in an increase in the concentration of salt. On the other hand, the salt concentration in a tidepool may be diluted by heavy rains and runoff, which will have little effect on the nearby open ocean environment. Pools which are further from the sea are more subject to fluctuations in salinity and temperature than those which are isolated from the open ocean for shorter periods of time during **tidal fluctuation** or changing tides.

Zonation and Tidal Fluctuation

Different shoreline and nearshore **zones** are identified according to how much they are covered by sea water or exposed to air by the changing tides. The zones we will be studying here include:

Splash zone: the portion of the shore above the reach of normal waves and high tide that is still regularly wetted by wave spray.

Intertidal zone: seaward of the splash zone, the region alternately covered and exposed by waves and the tide.

The **high intertidal zone** is only covered by water at high tide, but is always kept wet by waves.

The **low intertidal zone** is covered most of the time and exposed only during low tide, between waves.

Subtidal zone: the area continually covered by water, even at low tide.

These zones are summarized and illustrated on the handout entitled ***Limu* Habitat Notes**.

Shoreline topography and wave exposure

The above zones can be found on sandy as well as rocky shorelines, but are less obvious on sandy beaches. The distribution in bands, or **vertical zonation**, of *limu* can be observed readily on many rocky shorelines.

Zonation of *limu* and other marine organisms is also impacted by degree of **wave exposure,** influenced by **shoreline topography**, or the shape, size and position of physical elements of the shore. The size of waves and currents differs greatly from wave-sheltered bays and coves to open stretches of beach. The forms of *limu* vary with the environments, with those facing surf action tending to be stony, tough and/or flexible, and those in quieter water more delicate.

Large fleshy seaweeds (edible *limu* are all fleshy) are more abundant on flat areas, such as reef flats and limestone benches, than in wave surge environments at the **reef crest** and the steep, sloping seaward edge of reefs. These areas are dominated by stony **coralline algae**, seaweeds which deposit calcium carbonate and actually produce most of the reef through their growth.

Resources:

For Limu Study Field Sites

A list of appropriate sites for *limu* study field trips has been excerpted from DOE's Coastal Field Site guide, and is included in this module (pages C11-C14).

For complete site information and guidelines for field trip safety and preparation, please see:

A Compendium: Coastal Field Sites in the State of Hawai'i. State of Hawai'i Department of Education. RS 85-8050 (Rev. of RS 83-4146) June 1985.

For additional information about *limu* and their habitats

Abbott, Isabella Aiona. Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds. Lāwa'i, Kaua'i: Pacific Tropical Botanical Garden, 1984.

Fortner, Heather. The Limu Eater. Honolulu: University of Hawai'i Sea Grant College Program, 1979.

Magruder, William H. and Jeffrey W. Hunt. Seaweeds of Hawai'i. Honolulu: The Oriental Publishing Company, 1979.

NOTE: If sufficient copies of the above three books are available, students could use them as references to complete the **Prediction Worksheet**, instead of or in addition to the ***Limu* Habitat Notes** and **Notes on *Limu* Distribution** provided here.

For additional background information:

Shoreline zonation:

AECOS, Inc. 1982. Hawaiian Shoreline and Nearshore Ecosystems. Honolulu: University of Hawai'i Sea Grant Advisory Services, Working Paper No. 50.

Distribution and succession of marine algae in Hawai'i:

Doty, Maxwell S. 1967. Pioneer intertidal population and related general vertical distribution of marine algae in Hawai'i. Blumea 15:95-105. Reprinted in A Natural History of the Hawaiian Islands, E. Alison Kay, ed. pp. 314-324. Honolulu: University of Hawai'i Press, 1972.

Crustoce coralline algae as major reef-builders in Hawai'i:

Littler, Mark M. 1973. The Population and Community Structure of Hawaiian Fringing-Reef Crustose Corallinaceae (Rhodophyta, Cryptonemiales). Journal of Experimental Marine Biology and Ecology 11:103-120.

Factors influencing growth of frondose (fleshy) seaweeds in Hawai'i:

Santelices, B. 1977. Water Movement and Seasonal Algal Growth in Hawai'i. Marine Biology 43:225-235.

Procedures:

Teacher preparation

It is recommended that the teacher pay a pre-field trip visit to the intended coastal site at low tide. This is important for safety as well as for activity planning. **Note:** Field trip should also be scheduled for low tide. For tides information, check a tides calendar, the daily paper, or the Sea Grant newsletter (call the Sea Grant Publications Office, 948-7410).

At the site:

1. Assess and plan around conditions which could pose possible shore, water, or weather hazards.

2. Note location of facilities, including phone, restrooms, shade, medical facilities, fire station.

3. Survey the inshore area to verify the presence of a number of species of *limu* . Take samples of *limu* back to the classroom for students to identify, prior to the field trip (see Module B).

4. Note whether there are an abundance of other kinds of seaweeds, besides the common edible seaweeds for which information is included in this module. Seaweeds of Hawai'i, and the keys to common seaweeds from the DOE's Field Keys to Common Hawaiian Marine Animals and Plants will be helpful, for teacher and students, in identifying these.

5. Determine the number and length of transect lines which would be appropriate for the site.

   Number: Plan to have students sample a diversity of habitats in their transects. The number of transect lines depends on the width of the study area and the types of areas available for study, e.g. tidepools, reef flat, stream mouth or spring. It also depends on the number of students in the class, working in teams of four or five on each transect.

   Length: Five to ten meters is recommended. For safety reasons, do not allow students to work close to the reef edge. Be sure to include the splash zone as well as a sampling of the intertidal area.

   Depth: A maximum depth of 50 centimeters of water at low tide is recommended for the study, for reasons of safety and ease of measurement.

In-class field trip preparation

1. Discuss with students: Have any of them picked *limu*? Do they know where to look to find different kinds? How do they know this? What makes a good place for *limu* to grow (**habitat**)?

2. Knowledge about *limu* habitat requirements helps us to know where to look for them. Ask students what *limu* need to grow. (Light, oxygen and carbon dioxide, nutrients, suitable substratum.) Discuss other factors which influence *limu* habitat: water depth, transparency or turbidity, water temperature, salinity, and water movement; tidal fluctuation; shoreline topography and wave exposure, and type of substratum.

3. Introduce concept of shoreline **vertical zonation**, including the terms **splash zone**, **intertidal zone (high** and **low)**, and **subtidal zone.**

4. Hand out copies of **Limu Habitat Notes**, **Notes on *Limu* Distribution**, the **Prediction Worksheet** and student instructions. Ask students to compiete the worksheets, predicting where, ideally, each of the *limu* listed would be found.

5. Discuss the features of the actual field trip site, then ask the students to check, on their worksheets, the kinds of *limu* they expect to find at that site. (Worksheets should be brought on the field trip, to allow students to compare predictions with their findings there.)

6. When scientists want to know about the population and distribution of kinds of organisms in an area, they sometimes sample the area to be studied, using **transects** and **quadrats**. Introduce these terms to the students:

transect: a cut, or line across a given area, along which information is collected about the kinds and numbers of certain objects or species

quadrat: a sampling plot used to study plant or animal life

7. Enlist student aid in preparing materials and equipment for the field study.

a) A transect line can be any kind of sturdy rope or cord marked off in meter intervals with waterproof ink. Length should correspond to the length of the study site.

b) Plastic bags are useful for collecting specimens. A blank label can be attached to each bag to provide a place to note the name of the specimen.

c) Quarter meter (.25 m^2) quadrats can be assembled from four sections of 1/4" polyvinylchloride (PVC) pipe, cut into 50 centimeter lengths. Attach a 1/4" PVC elbow to each length of pipe with PVC cement. Drill about three holes through each section of pipe so that it won't float (away!). The sections of the quadrat with attached elbows can be joined after reaching the field study site, to allow for ease in transporting them.

Using waterproof ink, one side of the quadrat can be marked off in centimenters, for ease in measuring depths. (Students can flip the quadrat up on its side and use it like a ruler.)

d) Clipboards can be made from any sturdy backing, such as corrugated cardboard from large boxes, in pieces approximately 9 x 12 inches. A large clip or clamp will hold papers on the backing. Attach field study worksheets, one per quadrat to be studied. A plastic bag could be attached as a protection over the top sheet.

8. Hand out **Transect Study Procedures**, and preview procedures for doing a transect study. If students have not done transect studies in earlier grades, it may help to do a "dry run." Commonly occuring objects (floor tiles, desks, plants) can serve as the "organisms" to be studied.

a) Lay a transect line in a straight line from one marker to another, in or out of doors.

b) Center a quarter meter quadrat over one end of the transect so that it covers 25 cm on each side of the transect (see illustration on **Transect Study Procedures**).

c) Ask students to count and record the number of certain organisms inside the quadrat. Repeat procedure for several quadrats along the transect until students get the idea.

9. Note the difference in procedures for estimating population: **counting separate objects**, and **estimating the percentage of cover** by kinds of *limu* within a quadrat. (Why might it be difficult to count individual *limu*?) Students can use the meter quadrats around the school to practice estimating percentage of cover. Invite them to estimate percentage of cover by papers on the bulletin board, the writing on the blackboard, or desks on the floor in the classroom.

10. Demonstrate any of the measurements which may be new to the students, e.g. the use of a hydrometer, oxygen meter or Winkler test, or the kits for testing nitrogen or phosphorus (optional).

11. Review field trip safety procedures, conservation guidelines, and rules of conduct for students.

Field trip

1. Divide students into teams of four or five, and give each team a number (or ask them to select a team name). Each student team will run a transect line from a designated distance outward from shore, accessible at low tide, in to the splash zone. Both ends of the transect line can be tied to rocks to keep the line in place.

2. Teams should start working at the makai end of their transects. If the transects are parallel, every **other** team could begin one half meter in from the end of the transect, so that as the teams study one quadrat per meter, a "checkerboard" pattern of sampling is taking place over the site.

3. Remind teams to face the ocean at all times and to work carefully but quickly as the tide returns. Place the quadrat in the water so that it is centered over the transect line. For each quadrat, teams should follow these steps, with students taking different responsibilities:

a) Record team number (or name) and the **distance** in meters of the quadrat **from shore**.

b) List on the worksheet the **different kinds of *limu*** found in the quadrat. If there is a kind students aren't sure of, note it as "type a" or "type b" etc. and use the field key to identify it when back on shore.

c) **Collect** one or two small **specimens** of each kind of *limu*. Follow conservation guidelines in collecting. Cut or snap the stipe **above** the holdfast. Place each kind of *limu* in a separate plastic bag, and write its name or "type a" etc. on label. [**Note:** at the end of the day, save any extra *limu* specimens for pressing. See Appendix 2 for instructions.]

d) Estimate the **percentage of cover** by each type of *limu* in the quadrat. Record this estimate for each quadrat.

e) In each quadrat, different team members can be responsible for measuring and reporting some or all of the following environmental factors:

average **water temperature**, with a thermometer
average **water depth**, with a ruler or the side of the quadrat, marked in centimeters
water density (related to salinity), with a hydrometer
dissolved oxygen, with an oxygen meter
(or take a sample back to class for a Winkler test)
nitrogen and/or **phosphorus**, with appropriate testing kits

f) One student in each team can record the information for the other team members, and be responsible for **sketching a map** of each of the quadrats studied. Maps should highlight features such as different substrata, cracks and crevices, fresh water inflow, or tidepools.

4. Move the quadrat in toward shore one meter and repeat steps 2 a-f. Study one quadrat per meter the length of the transect line.

5. On shore, if there are any questions, use field keys to identify or verify kinds of *limu* . Add this information to the quadrat worksheets.

6. Optional: Teams can organize their findings on the **Transect Profile Worksheet**, in preparation for the Summary Discussion.

Post-field study discussion

Note: Post-field trip discussion can take place back in the classroom if more time is needed, if site isn't comfortable for large group discussion, or if easle and newsprint are difficult to locate and transport.

On a large sheet of paper on an easle, prepare a simple matrix to record the students' discussion contributions (see sample illustration on next page). Ask students to refer to their **Prediction Worksheets** and **Field Study Worksheets** (or **Transect Profile Worksheets**) to discuss the following:

1. What **kinds** of *limu* were found in this site? (Compile a group list on the large paper.)

2. How were these *limu* **distributed**, that is, in which quadrats were they found? (Mark each quadrat with a check [ ].)

3. Where was the **percentage of cover greatest** by each kind of *limu* ? (Ask for estimated percentages to determine which is greatest. Different *limu* may dominate in different quadrats along the various transects. Mark quadrats with greatest percentage of cover by each *limu* with a star [*].)

4. If there are noticeable **differences between transects** in the the kinds and distributions of *limu* , ask students to hypothesize what environmental factors might account for the differences. (Refer them to their **Field Study Worksheets**.)

5. Looking at the specimens of the dominant *limu* for the various quadrats, ask students to consider how the physical features of those *limu* might be **adapted** to the environmental conditions where they dominate.

6. Now ask the students to decide which **zones** are represented in the quadrats studied. Write "splash zone," "intertidal," (high or low) and "subtidal" above the numbered quadrats.

7. Ask students to compare their **Prediction Worksheets** with the information on the matrix. How do the **field study findings compare with students' predictions** about where different kinds of *limu* would be found? How might they account for any unexpected findings? Ask students to hypothesize possible influential factors.

(In addition to data which students collected about specific features in each quadrat, students might consider the impact of other possible factors, such as recent storms or high surf, *limu* pickers, or aggressive introduced species of seaweed taking over habitat.)

8. Ask students to use the information they gathered about environmental factors to propose some generalizations about where to look for particular kinds of *limu* in the future.

MATRIX FOR SUMMARY DISCUSSION

	splash zone	intertidal							subtidal	
	QUADRAT									
KINDS OF *LIMU* FOUND	1	2	3	4	5	6	7	8	9	10

Coastal Field Sites Suitable for Limu Study

Excerpted from: A Compendium: Coastal Field Sites in the State of Hawai'i. State of Hawai'i Department of Education. RS 85-8050. (Rev. of RS 83-4146) June 1985. Sites are included in this list only if the entry in the Coastal Field Sites guide mentioned the presence of seaweed. Other sites may be appropriate as well. Check Coastal Field Sites for complete site and field trip planning information. *See especially* section A, Field Trip Safety and Preparation.

O'ahu

p. O-7	Kewalo Basin	Tidepools, intertidal areas and reef flats. At different times of year, abundant seaweed materials are present, primarily *Acanthophora, Ulva,* and *Padina.*
p. O-11	Reef flat on Hickam Air Force Base	A limited variety of algae is present.
p. O-19	'Ewa Beach Park	Beach, reef flat. Many species of limu are abundant but can disappear in a single tide change. This is one of the most popular limu picking areas on O'ahu.
p. O-27	Mā'ili Beach Park	Different types of seaweed grow on the reef flat.
p. O-31	Mā'ili Point Reef	Seaweed is present in small amounts on the reef flat and intertidal area.
p. O-35	Lualualei Beach Park	Tidepools, reef flat. Algae are dense near the seaward edge of the reef.
p. O-39	Ka'ena Point State Park	Tidepool and reef flat. Tidepool biota includes limu.
p. O-43	Mokulē'ia Beach Park	Tidepool, reef flat. The narrow reef flat along the beach displays a sharp intertidal zonation of limu and marine organisms.
p. O-47	Kaiaka State Recreation Park	Tidepools, estuary, reef flat. Reef biota includes algae.
p. O-59	Mālaekahana State Park	Beach, reef flat. At different times of year, abundant seaweed drift material is deposited along the beach.
p. O-67	Kualoa Regional Park	Reef flat. Various species of algae are found off-shore.
p. O-77	He'eia Fishpond and Mangrove Marsh	The intertidal reef contains a number of algae species.
p. O-81	King Intermediate School Reef Flat	Tidepools, reef flats, intertidal microhabitats on concrete pilings. Limu are found along the coastal area.

O'ahu, continued

p. O-109	Kawaiku'i Beach Park	Beach, reef flats. *Ectocarpus* algae are found washed up on the beach in large quantities. The off-shore reef area contains a variety of algae species.
p. O-112	Wai'alae Beach Park	There are a number of algae [species] on the off-shore fringing coral reef.
p. O-117	Diamond Head Beach Park*	The off-shore area is an uneven coral reef flat containing pockets of sand. There are a number of [species of] algae.
p. O-121	Reef Behind Waikiki Aquarium*	The reef flat, extending outward from the beach about 35 yards, has a variety of limu species including *Turbinaria, Padina, Dictyopteris plagiogramma,* and *Sargassum.*

***NOTE:** The reef area is part of the Waikiki-Diamond Head Shoreline Fisheries Management Area. According to the current cyclical management scheme, the area from Kapahulu groin to Diamond Head Lighthouse, outward 500 yards or to the edge of the reef (whichever is greater), is **closed to** all forms of fishing, including **limu picking**, for two years (until June 30, 1988). Contact the Hawai'i State Department of Land and Natural Resources, Division of Aquatic Resources (548-5915) for updated information or any policy changes.

Maui

p. M-5	Pu'unoa Beach Park	Sandy and cobble-stone beach, tidepools/intertidal area. Marine algae are present in the cobblestone beach area.
p. M-9	Launiupoko State Wayside Park	Tidepools, intertidal area, reef flat with algae.
p. M-15	Mā'alaea Small Boat Harbor	Tidepools, intertidal area, reef flat. The offshore area contains marine algae.
p. M-21	Waipu'ilani Reef Flat	Tidepools, fish pond, reef flat. On the shallow submerged portion of the reef flat one can find various types of marine algae.
p. M-29	Hāmākua Poko Papa or H-Poko Papa Beach Park	Zonation of marine algae and animals is exhibited over an exposed and unprotected reef platform.
p. M-31	Ho'okipa County Beach Park	Intertidal areas, reef flat. The tidepool biota includes marine algae.
p. M-41	Hāmoa Tidepools	Tidepools, intertidal area, reef flat are rich with algae.

Kaua'i

p. K-3	Maha'ulepu Beach	Tidepools. Many types of marine life are found in this area including seaweed.

Kaua'i, continued

p. K-15	Kapa'a Beach Park	The reef flat and tidepools support a wide variety of marine life that includes seaweeds.
p. K-19	Anahola Beach Park	The reef flat fronting the beach park contains a wide variety of marine life that includes seaweed.
p. K-27	'Anini Beach Park	The 'Anini Reef exhibits a wide diversity of marine life including seaweeds--attracting many seaweed harvesters.
p. K-31	Ha'ena State Park (Ke'e Beach)	The reef flat offers a good diversity of marine life that includes seaweeds.

Hawai'i

p. H-11	Harry K. Brown Park	Except for beach drift of miscellaneous algae and sponges, very few marine algae or animals can be found on the black sand beach.
p. H-19	Richardson Ocean Center Beach	*Limu 'ele'ele* can be found in the anchialine ponds; in the splash zone can be found *limu 'aki'aki.*
p. H-23	Leleiwi Beach Park	Beach drift includes *limu wāwae'iole, 'ele'ele, 'aki'aki, kala,* and *pālahalaha.*
p. H-39	Laupāhoehoe Beach Park	*Ahnfeltia (limu 'aki'aki)* can be found in the tidepools.
p. H-55	'Anaeho'omalu Bay	Coralline algae encrusts the anchialine ponds and the tide pools interspersed on the north and south sides of the bay.
p. H-59	Keāhole Point (Natural Energy Laboratory of Hawaii [NELH], OTEC Beach)	*Ulva (limu pālahalaha), Padina,* and *Sargassum (limu kala)* are present in tidepools.
p. H-63	Old Kona Airport State Park, Kūkā'ilimoku	Limu is sparse in tidepools on the northern portion, but tidepools on the south side have an abundance of seaweed, especially *limu kala, pālahalaha, kohu, 'aki'aki.*
p. H-67	Kahalu'u Beach Park	Limu is sparse, but some *limu 'aki'aki* and *pālahalaha* are present.
p. H-71	Pu'uhonua o Hōnaunau National Historical Park, Hōnaunau Bay (Formerly City of Refuge)	There is a significant amount of *limu pālahalaha* growing on the reef. [Note: *Limu* collecting not allowed.]

Moloka'i

p. ML-3	Mo'omomi Beach	The long stretch of shoreline from Mo'omomi to Keonelele Beach contains a wide variety of marine life including seaweeds.
p. ML-7	Kiowea Park	The shallow mudflats contain a number of diverse marine life including seaweeds.
p. ML-11	Onealiʻi Beach Park	The shallow mudflats harbor many different types of marine life, including various seaweeds.
p. ML-15	Murphy Beach Park	Tidepools and shallow fringing reef. Marine life here includes seaweeds.

Lānaʻi

p. L-3	Hulopoʻe Beach Park	The tidepools offer excellent opportunities for field trip explorations and contain seaweeds.

Limu Habitat Field Study Preparation

Prediction Worksheet
Student Instructions

We will be going to a field study site on the coast to look for various kinds of *limu*. The **Prediction Worksheet, *Limu* Habitat Notes,** and **Notes on *Limu* Distribution** are tools for thinking ahead about where we might find each kind of *limu*.

1. Read the ***Limu* Habitat Notes** and **Notes on *Limu* Distribution**. Pay special attention to the names of the different zones, if these are new to you.

2. Use the information in the **Habitat** and **Distribution Notes** to complete the **Prediction Worksheet**. Write the following on the Worksheet for each kind of *limu*, starting from the far left column:

   a. the Hawaiian and scientific name of this *limu*

   b. the initial of the Hawaiian islands where this *limu* can be found (see the list at the bottom of the worksheet)

   c. "C" if this *limu* is common, or "R" if it is rare, uncommon, or seasonal

   d. an "X" in the column or columns for the zones where this *limu* grows

   e. the initial or initials for the types of substratum, or bottom, on which this *limu* grows (see the suggestions at the bottom of the worksheet)

   f. notes about any other special features of the habitats where this *limu* is found, for instance: brackish water, calm water, constantly moving water, turbid water, tide pools, sea urchin holes or crevices (cracks).

3. When you know what field study site we will be going to, put a check mark by the names of the *limu* you predict we will find there. Use your knowledge of the features of the site, and the ***Limu* Habitat and Distribution** information.

4. Bring your Prediction worksheet with you to the field study site, to compare with your findings there.

PREDICTION WORKSHEET

Name of *Limu*	islands	common/rare	splash zone	low intertidal	high intertidal	subtidal	substratum	Other Habitat Features

O = O'ahu
M = Maui
H = Hawai'i

K = Kaua'i
ML = Moloka'i
L = Lāna'i

B = basalt
L = limestone
S = sand

Limu Habitat Notes

Near Shore Zonation:

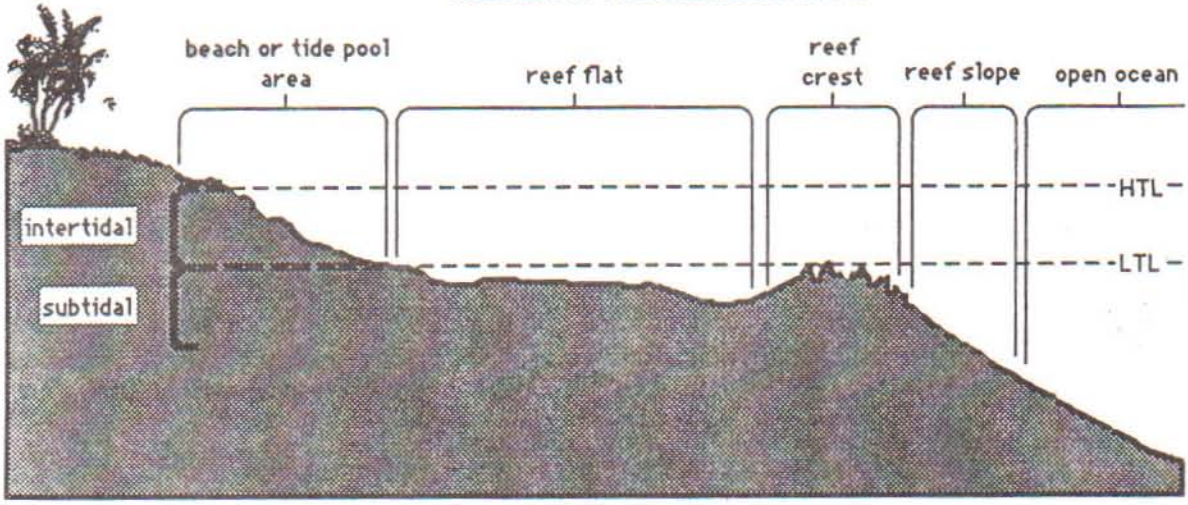
The **splash zone** is the portion of the shore above the reach of normal waves and high tide, but regularly wetted by wave spray.

The **intertidal zone** is that part of the shore which is covered, then exposed, as the tide changes.

The **high intertidal zone** is only covered with water at high tide.
The **low intertidal zone** is covered most of the time and only exposed at low tide.

The **subtidal zone** is always covered with water, but includes tidepools as well as deeper water.

Habitats of Hawaiian Seaweeds



HTL: high tide level **LTL:** low tide level
Adapted from Magruder, William H. and Jeffrey W. Hunt, Seaweeds of Hawai'i, p. 9.

Habitat Notes for Selected Hawaiian *Limu*

Limu 'ele'ele (Enteromorpha prolifera)
Common in brackish (mixed fresh and salty) water, such as at the mouth of a stream, in an oceanside pond or near a spring at the edge of the sea. Usually grows on small rocks buried in fine sand.

Limu pālahalaha, pāpahapaha, pakaiea (Ulva fasciata)
Common and abundant in areas with freshwater influence. Found in a range of intertidal and subtidal habitats, from calm shallow tidepools and slightly brackish water, to a depth of more than five feet on reefs. Especially common on lava rock and old coral.

Limu wāwae'iole, 'a'ala, 'a'ala'ula (Codium edule, C. reediae)
Common and locally abundant over reef flats. *C. edule* found in low intertidal and especially subtidal habitats, six to ten feet deep. *C. reediae* found subtidally, in calm, deep tidepools and reef flats.

Limu līpoa (Dictyopteris plagiogramma, D. australis)

Abundant where found, generally in deep water (3-40 feet) outside reef crests or occasionally on reef flats. *D. plagiogramma* is also found on rocky shores at zero tide level (average lower low tide). Both species are found as shore drift, year round.

Limu kala (Sargassum echinocarpum)

Common in intertidal zone, in rocky and sandy places, on wave-swept lava benches, from warm, calm tide pools to depths of more than ten feet over reef flats.

Limu pahe'e (Porphyra species)

Uncommon and highly seasonal, found occasionally in winter and early spring, following periods of high surf. Grows on exposed lava boulders, high in the wave-splashed intertidal zone, usually in areas with fresh water influence.

Limu kohu, koko, līpehe, līpa'akai (Asparagopsis taxiformis)

Common seasonally in shallow subtidal zone where there is constant water motion, such as on reef crests. Also grows well on intertidal lava benches.

Limu huluhuluwaena, pakeleawa'a (Grateloupia filicina)

Found occasionally, on shallow reef flats or rocks covered with sand in intertidal zone. Usually found in areas with fresh water influence, such as near springs or stream mouths.

Limu lepe 'ula'ula, lepe-o-Hina (Halymenia formosa)

Uncommon, grows subtidally to depths of twenty feet, often in slightly turbid conditions (muddy or stirred up). Frequently washes up on shore.

Limu manauea (Gracilaria coronopifolia)

Formerly common, now less so. Grows on shallow reef flats, occasionally in tide pools, and is often washed up on shore. Another species, *Gracilaria parvispora (long ogo)* grows on calm reef flats.

Limu 'aki'aki (Ahnfeltia concinna)

Abundant where present. Grows at very high intertidal level on rugged lava coastlines, sometimes as a distinct, dense band covering the exposed lava rock, or only in small crevices and cracks.

Limu līpe'epe'e (Laurencia succisa)

Common intertidally in areas with moderate to heavy surf, especially in small pools of *a'a* basalt or limestone. Grows downward into crevices or sea urchin holes, and may be found under larger seaweed.

Limu mane'ene'o, māneoneo (Laurencia nidifica)

Common in lower intertidal zone, sometimes deeper. Grows on sandy and eroded reef rock.

Sources:

Abbott, Isabella Aiona. Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds. Lāwa'i, Kaua'i: Pacific Tropical Botanical Garden, 1984.

Fortner, Heather. The Limu Eater. Honolulu: University of Hawai'i Sea Grant College Program, 1979.

Magruder, William H. and Jeffrey W. Hunt. Seaweeds of Hawai'i. Honolulu: The Oriental Publishing Company, 1979.

Notes on *Limu* Distribution

Excerpted from: Abbott, Isabella Aiona. Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds. Lāwa'i, Kaua'i: Pacific Tropical Botanical Garden, 1984.

Limu 'ele'ele (Enteromorpha prolifera)

Near freshwater streams entering ocean or underwater springs such as are found at Ho'okena and Punalu'u on Hawai'i; Puko'o, Moloka'i; Kahala and Hau'ula, O'ahu; Hanapepe and Hanalei, Kaua'i.

Limu pālahalaha, pāpahapaha, pakalea (Ulva fasciata)

Common throughout islands.

Limu wāwae'iole, 'a'ala, 'a'ala'ula (Codium edule, C. reediae)

C. edule common throughout islands. On O'ahu, especially at Waikīkī, Kawela Bay and Nānākuli; on Maui at Kīhei. C. reediae found from 'Ewa Beach to Sand Island on O'ahu and on the southwestern shore of Maui.

Limu līpoa (Dictyopteris plagiogramma, D. australis)

Found at Nōmilu, Kaua'i; Kāne'ohe to the Blowhole and Waikīkī, O'ahu; Olowalu and Lahaina, Waihe'e to Sprecklesville, Maui; Kohala, Hawai'i.

Limu kala (Sargassum echinocarpum)

Common throughout islands.

Limu pahe'e (Porphyra species*)*

Seasonal. On all large islands in areas with heavy surf and fresh water: Mōloa'a and Kalihiwai, Kaua'i, Waimea and Mā'ili, O'ahu; Honolua, Pā'ia, and Hāna, Maui; Kohala, Kona, Waikapuna, and Ka Lae, Hawai'i.

Limu kohu, koko, līpehe, līpa'akai (Asparagopsis taxiformis)

Occasional on all major islands. Especially Anahola district of Kaua'i; also Wai'anae, Hau'ula and Kahuku, O'ahu; Moloka'i; Hāna and Pā'ia, Maui; and Kohala, Hawai'i.

Limu huluhuluwaena, pakeleawa'a (Grateloupia filicina)

Occasional on all major islands: Honokowai, Mā'alaea, and Māla, Maui; Kupeke, Moloka'i; Waikīkī and Hanauma Bay, O'ahu; Hilo, Hawai'i.

Limu lepe 'ula'ula, lepe-o-Hina (Halymenia formosa)

Off Kahala, Kailua, Hau'ula, and 'Ewa Beach, O'ahu; Kama'ole, Kīhei, and Kahului, Maui; Laupāhoehoe and Kona, Hawai'i.

Limu manauea (Gracilaria coronopifolia)

Formerly common on O'ahu. Grown commercially on the North Shore.

Limu 'aki'aki (Ahnfeltia concinna)

Rare on O'ahu. Common on Maui, on Hawai'i, and at Hanama'ulu, Kaua'i.

Limu līpe'epe'e (Laurencia succisa)

Common except on Hawai'i. Poipū, Kaua'i; Hālona and Mauna Lahilahi, O'ahu; Hāna, Maui.

Limu mane'ene'o, māneoneo (Laurencia nidifica)

Common on all islands except Hawai'i. Kapa'a, Kaua'i; Kualoa to Lā'ie, O'ahu; Mā'alaea and Pā'ia, Maui.

Transect Study Procedures

transect: a cut, or line across a given area, along which information is collected about the kinds and numbers of certain objects or species.

transect line: a linear measuring tool, marked at regular intervals, used in the study of a transect

quadrat: a sampling plot used to study plant or animal life; also, the tool used to mark out this study plot.

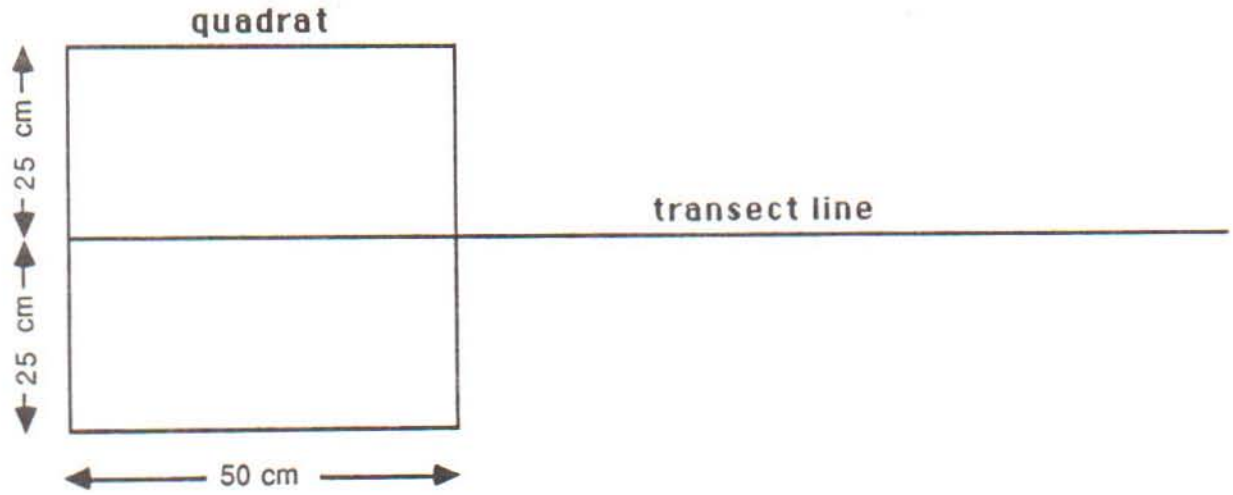
In our field study, we will sample the *limu* **distribution** (where each kind is found) and the percentage of the area covered by each kind of *limu* at the site. To do this, we will be using transect lines marked off in meters, and quarter meter quadrats (50 centimeters on a side, or .25 m^2).

Here are the steps for using these tools:

1 Lay a transect line in a straight line from one marker to another.

At the coastal field site, this line will run from a point in the water in to shore, at right angles to the general shoreline.

2. Center a quadrat over the end of the transect line so that it covers 25 centimeters (cm) on each side of the transect line, as in the illustration:

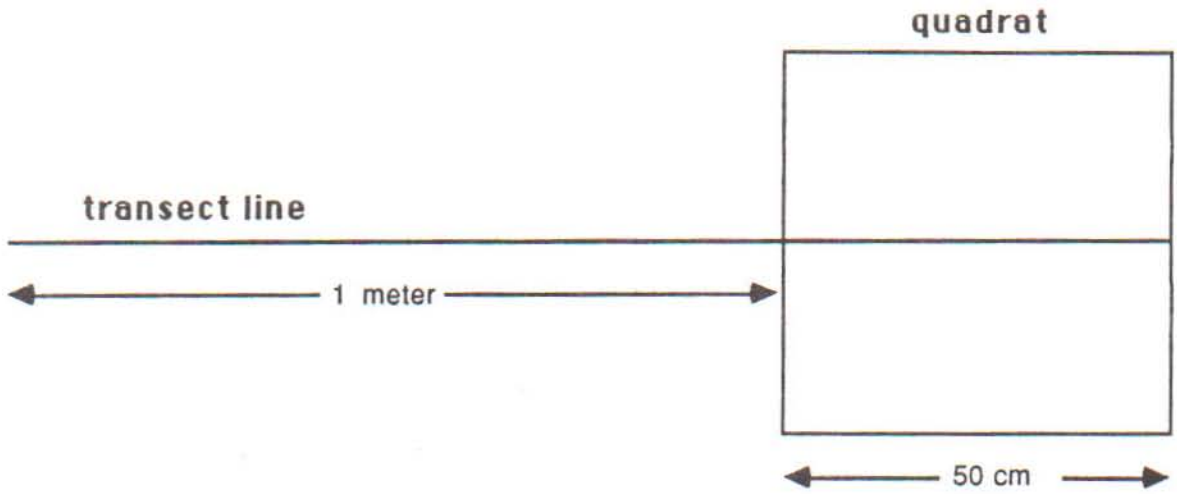


At the coastal field site, the first quadrat studied will be at the *makai* end of the transect line. We will begin our study at low tide, but the tide will be coming in, so we'll have to work quickly and carefully.

3. Count and record the number of specified plants or animals within the quadrat.

At the field site, we'll be **estimating percentage of *limu* coverage** of the area inside the quadrats, rather than counting individual *limu*. For our study, we'll be focusing on *limu* which is at least **two inches long.**

4. Each team will study every **other** quadrant along their transect line. To study the second quadrat, place the quadrat along the transect line as shown in the illustration:



5. Count and record the number of specified plants or animals within the second quadrat.

Again, in our study, we'll be estimating percentage of cover rather than counting individual *limu*.

6. Place the quadrat over the third quadrat area and so on along the length of the quadrat, and count (or estimate percentage of cover) and record information for the specified plants and animals for each quadrat.

Field Trip:

Field Study Worksheet

For each quadrat studied along the transect line, fill in one Field Study worksheet as follows:

1. Write the number or name of your transect team, and the **number of meters** from shore the quadrat is located.

2. **Locate and identify the different kinds of *limu*** within the quadrat. For this study, focus only on *limu* two inches long or larger. Write on the worksheet the names of any kinds of *limu* you find.
(If there are any kinds you can't name, just call them "Type A", "Type B" and so on for the time being.)

3. **Estimate the percentage of cover** by each type of *limu* in the quadrat. Record these estimates next to the name of each *limu* .

4. **Collect a small specimen** (sample) of each kind of *limu* within the quadrat. Cut or snap the **stipe** of the *limu* --don't pull it out by its **holdfast**.

   Put the specimens in separate plastic bags and write the name or "Type A" etc. on the label. Back on shore, you can use this specimen to identify the *limu* by using the field key.

5. For each quadrat, different members of your team can:

   a. **measure and record** the **average water depth** (use plastic ruler)
   b. **measure and record average water temperature** (use plastic thermometer)
   c. **measure and record water density** (use a hydrometer; later on, water density can be used to estimate **salinity)**
   d. if testing kits are available, **measure and record concentrations of oxygen, nitrogen, and or phosporus**
   e. **sketch a map** of each quadrat, emphasizing **other features** which could be affecting *limu* habitat. These features could include: the type of substratum, presence of boulders or other surfaces, tide pools, sea urchin holes or crevices; and water conditions such as brackish, calm, constantly moving, or turbid.

Field Study Worksheet

Transect Team: _____

Number of meters from shore: ____

kind of *limu*	% cover

water temperature: _____

water depth: _____

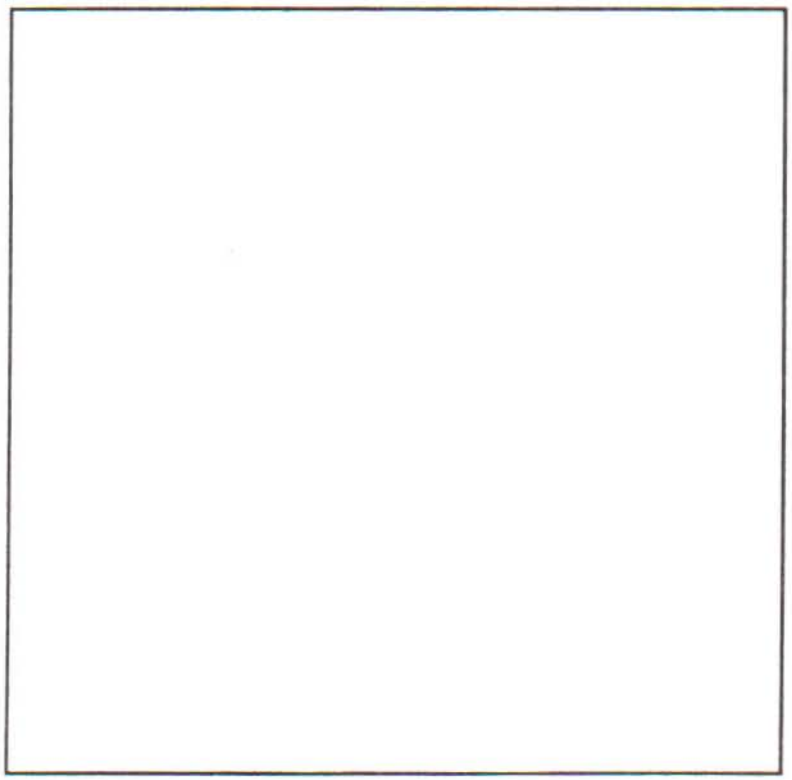
water density: _____

dissolved oxygen: _____

nitrogen: _____

phosphorus: _____

Sketch a map and label quadrat features:



TRANSECT PROFILE

Transect: ____

zones	quadrat #	transect sketch	kinds of *limu* found	environmental factors

D. *Limu* in Tradition and Legend

Subject Areas: Hawaiian Studies
Hawaiian Language
Language Arts

Key Concepts:

Limu was an important part of traditional Hawaiian life, used not only for food, but for medicine and ritual as well.

Legends can provide some clues to the roles of *limu* in traditional Hawaiian society.

Activity Objectives:

Students will recognize some of the roles *limu* played in traditional Hawaiian society.

Students will be able to find and compare references to *limu* in Hawaiian legends with other information about *limu* in traditional Hawaiian life.

Skills Emphasis: reading comprehension
conducting research
categorization and comparison

Vocabulary:

'ai	*i'a*	*kino lau*	microbenthos

Materials:

a copy for each student:

reading: **Some Traditional Hawaiian Beliefs and Practices related to *Limu*.** (D7)

optional: the newspaper article, **"Hawaiian Uses of Limu"** by Russ Apple, January 6, 1984, Honolulu Star Bulletin. (D9)

optional: the legends, *Kūka'ōhi'aakalaka* and *Hinaikeahi a me Hinaikawai*, in Hawaiian and English. (D11-D17)

Time Needed: two class periods, with homework assignment

Background:

Legends and myths can be viewed as kinds of artifacts, in that they come to us from the past, and contain clues to the ways people formerly talked, acted and thought about various aspects of life Like archaeological artifacts, legends are a residue of performance, a part of a complete picture which is now separated from its living context. Sometimes legends relate a picture of life which is not actual but metaphorical, so care must be taken in interpreting all aspects of legends literally.

Many Hawaiian legends contain references to *limu*, although in most cases *limu* is not the central focus of the story. For instance, many times women are depicted going to pick *limu*, or a meal is prepared which includes *limu*. These references reflect the real life in that most *limu* was picked by women, and that *limu* was a regular part of the traditional Hawaiian diet.

An annotated list of more than two dozen Hawaiian legends which contain references to *limu* is included with this module. There are certainly others. Some of the legends appear in more than one collection, and in more than one version

Procedure:

1. Review the annotated list of legends (pages D4-D6) and select those appearing in collections which are readily available to students. Supplement the list with any other legends which are available and contain *limu* references.

2. Introduce students to the notion that legends, like archaeological artifacts, contain clues to the activities and attitudes of people in the past. In this activity, students will be asked to look for clues in Hawaiian legends about the roles played by *limu* in traditional Hawaiian life.

3. As a homework assignment, ask each student to read at least one legend and find the reference to *limu*. Ask students to summarize in one or two sentences what roles *limu* plays in the legends they read.

Optional: for Hawaiian language classes, students might read the legends, *Kūka'ōhi'aakalaka* and *Hinaikeahi a me Hinaikawai*, in Hawaiian. (pages D11-D17)

4. Compile a class list of references to*limu* in the legends, then categorize the references, for example: references to women picking *limu*, *limu* as a ritual symbol, *limu* as a substitute for fish. Ask students to summarize the conclusions they could draw from these references to *limu*. Collect and post or distribute copies of the class conclusions.

5. Distribute the reading, **Some Traditional Hawaiian Beliefs and Practices related to *Limu*** (page D7). Ask students, working in small groups, to discuss the categories of *limu* use in this account, and compare them with the class findings from the *limu* references in legends. For instance, what uses are included in the reading that were not mentioned in the legends the students read? Did the legends include references not mentioned in the reading?

Optional: Students can also read and compare the findings in Russ Apple's article, **"Hawaiian Uses of Limu."** (page D9)

6. **Extension:** Students could conduct research, using resource materials such as those listed on the next page, to discover in more detail traditional Hawaiian uses of *limu* . Students could report their findings to the class.

Resources:

Abbott, Isabella Aiona. 1984. Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds. Lāwa'i. Kaua'i: Pacific Tropical Botanical Garden.

Akana, Akaiko, Akina, J. K. and Kaaiamanu, D. M. 1968 (1922). Hawaiian Herbs of Medicinal Value. Honolulu: Territorial Board of Health Bulletin, reprinted by Pacific Book House, Honolulu. [See pages 59-63.]

Bryan, E. H., Jr. 1933. Hawaiian Nature Notes. Honolulu: Honolulu Star Bulletin, Ltd. [See pages 138-143.]

Curtis, Caroline. 1970. Life in Old Hawai'i. Honolulu: The Kamehameha Schools Press. [See pages 33-37.]

Fortner, Heather J. 1978. The Limu Eater: A Cookbook of Hawaiian Seaweed. Honolulu: University of Hawai'i Sea Grant College Program. [See pages 27-31.]

Gutmanis, June. 1985 (1976). Kahuna Lā'au Lapa'au. Honolulu: Island Heritage. 3rd edition. [See pages 30, 37-38, 40-41, 45.]

Handy, E. S. Craighill, Mary Kawena Pukui and Katherine Livermore. 1976 (1934). Outline of Hawaiian Physical Therapeutics. Honolulu: Bishop Museum Bulletin 126, reprinted by Kraus Reprint Co., Millwood, New York. [See page 14 and pages 44-45.]

Malo, David. 1951. Hawaiian Antiquities. Honolulu: Bishop Museum Special Publication 2. [See pages 45, 97-98.]

Reed, Minnie. 1907. The Economic Seaweeds of Hawai'i and Their Food Value. Annual Report of the Hawaiian Agricultural Experiment Station: 1906. Washington, D. C.: U. S. Government Printing Office. [Pre-contact and early 20th century Hawaiian uses. See pages 61-77.]

Summers, Catherine C. 1964. Hawaiian Fishponds. Honolulu: Bishop Museum Press Special Publication 52. [See pages 2-6, 12, 22.]

Taylor, Leighton (ed.) 1981. Hawaiians and the Sea. Honolulu: Waikiki Aquarium. [See pages 3 and 22.]

NOTE: Some may be familiar with a Hawaiian legend concerning ***limu make o Hāna*** (deadly seaweed of Hāna). According to the legend, this *"limu"* became poisonous after a group of fishermen, suspicious of a man they thought responsible for the disappearance of several people, killed the man, burned his body and threw the ashes into the sea. At the tidepool in Hāna where this happened, the legend says, the *"limu"* became toxic. Actually, this *"limu"* is **not a seaweed**, but an anemone-like marine animal of the coelentrate family. It has also been found in surge pools at Lāna'i Lookout, and at the Blowhole on O'ahu. While the palytoxin in this organism can be fatal in large enough doses, scientists have been exploring the potential medical use of smaller doses. See:

Moore, Richard E. and Paul J. Scheuer. 1971. "Palytoxin: A New Marine Toxin from a Coelenterate." Science (172) 495-498.

Matsunaga, Mark. 1979. "Isle Limu May be Enlisted in the Fight Against Cancer." Honolulu Advertiser, December 12, page B4.

Ambrose, Jeanne. 1982. "Hana's Poisonous 'Limu' May Hold Key to Cancer." Honolulu Star Bulletin, May 21, page A16.

Some Hawaiian Legends Containing References to *Limu*

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

'Aumākua Legends, pp. 132-133. [A young girl gives birth to a shark, offspring of a shark god. She wraps it in green *pakaiea (limu)* and casts it into the sea. This green-coated shark became the *'aumakua* of that family, who thereafter eat no shark flesh or *pakaiea*.]

Elbert, Samuel H. (ed.) 1959, 1965. Selections from Fornander's Hawaiian Antiquities and Folk-lore. Honolulu: University of Hawai'i Press. [in Hawaiian and English]

Legend of Kawelo, chapter VI, Relating to Kauahoa, Kawelo Fears to Attack Him, Seeks to Win Him with a Chant, Kauahoa Replies, pp. 92-96. [A chant refers to the "moss" (*limu)* at Hanalei.]

Story of 'Umi, chapter V, How 'Umi Became the King of Hawai'i, pp. 142-148. [A large ball of *limu* is sometimes collected in place of men for a sacrifice.]

Green, Laura S. (Martha W. Beckwith, ed.) 1928. Folk-Tales from Hawai'i. Honolulu: Hawaiian Board Book Rooms. [in Hawaiian and English]

Hinaikeahi a me Hinaikawai, pp. 56-59. [Hina-of-the-fire is buried in the *imu*. When the *imu* is opened, food is found in her stead, and she returns to her people from the sea, wreathed with *limu kala*.]

Johnson, Rubellite Kawena. 1981. Kumulipo: The Hawaiian Hymn of Creation. Volume 1. Honolulu: Topgallant Publishing Co., Ltd. (Other versions of the Kumulipo are available; this one presents Hawaiian and English on the same page, and includes some beautiful illustrations.) [Note: Although interpreting the Kumulipo may be too difficult for high school students, this reference is included for teacher information.]

Ka Wā 'Akahi (The First Era), pp.13-18; discussion pp. 77-93. Numerous seaweeds are listed in this Creation Chant, each one paired with a "guardian" land plant.

Kalākaua. (1972) The Legends and Myths of Hawai'i. Rutland, Vermont: C. E. Tuttle Company.

Lohi'au, the Lover of a Goddess, pp. 481-497. [Pele folks assume human form to enjoy water sports and gather seaweeds, etc.]

Hua, King of Hāna, pp. 157-173. [Hua orders his men to get him some particular birds from the mountains. His priest interjects that those birds would only be found at the sea in that season. When two men bring in the birds and say they caught them in the mountains, Hua's priest asks permission to cut them open, and doing so, shows them to be filled with small fish and bits of seaweed. Hua has the priest killed. See also the Pukui and Curtis version, below.]

Pukui, Mary Wiggin. 1933. Hawaiian Folk Tales, third series. Poughkeepsie, New York: Vassar College. [in Hawaiian and English]

Kūka'ōhi'aakalaka, pp. 146-149. [A stingy sister-in-law refuses to give her husband's sister some of their dried fish, so the sister has to gather *Ilpahapaha* to take back upland to her family.]

Pukui, Mary Kawena (collected or suggested) and Curtis, Caroline (retold). 1951. The Water of Kāne. Honolulu: Kamehameha Schools Press.

The Turtle in the Sweet Potato Patch, pp. 55-63. [A wedding feast is prepared by the *menehune*, including sweet potatoes, *poi*, fish, and seaweed.]

A Maiden from the Mū, pp. 67-75. [A man who lives among the Mū in the uplands longs for his old home by the sea and the taste of fish and *limu*.]

Kau'ilani and the Sea Monster, pp. 123-132. [Kau'ilani is told to look for his sister gathering shellfish and seaweed.]

The Sacred Breadfruit Tree, pp. 141-142. [Papa has gone to the beach to catch crabs and gather seaweed. Afterwards, when she stops at a stream to wash them, she sees her husband Makea being taken captive. In her haste to run after them, she spills some crabs and seaweed. She tears off the morning glory vines she was wearing for a *pā'ū*, and puts on a fresh *kapa*. To this day, crabs are sometimes seen where she spilled them at the edge of a little pool at Kilohana, and seaweed and beach morning glory vines still grow where Papa dropped them.] [Note: in Westervelt's version, the moss rooted itself by the spring but the crabs escaped to the sea.]

The Pipi of Pu'uloa [The Pearl Oysters of Pearl Harbor], pp. 158-9. [An old woman gathering seaweed comes across *pipi*, and takes one although she knows it is the *kapu* period. She is then punished by the *konohiki*, not once but twice. This angers the *mo'o* who brought the *pipi* to Pu'uloa in the first place, so she takes the *pipi* far away.]

The Song of the Kapa Log, pp. 162-7. [A meal of *poi*, shellfish and seaweed is shared with a woman of Kahuku who seeks her lost kapa log.]

The Punishment of Hua, pp. 201-207. ['Ua'u birds (the dark-rumped petrel) go inland to raise their young. In other seasons these birds are found at the seashore where their food is, and if caught and eaten then, they taste fishy. When two men bring in 'ua'u birds and say they caught them in the mountains, Hua's priest smells them and says they smell of the sea. Hua kills the priest.] [Note: in Kalākaua's version (cited above), the priest Luaho'omoe cuts the birds open and shows them to be filled with small fish and bits of seaweed.]

Thrum, Thomas G. 1907. Hawaiian Folk Tales: A Collection of Native Legends. Chicago: A. C McClurg & Co. Reprinted 1976, Folkcroft Library Editions.

Kalelealuaka, pp. 74-106. Part III. [Kalelealuaka sends his wives for shrimps and moss to be gathered in a particular way. When the two of them return with the moss and shrimps, he complains that the moss was not gathered as he had directed, and they were gone so long he's not hungry anymore. This is one of many similar incidents in which they cannot please him.]

Kū'ula, the Fish God of Hawai'i, pp. 215-229. [In revenge on the King and the people of Hāna who had attacked him, Kū'ula and his wife enter the sea and take away with them every edible thing in the area of Hāna--fish, sea-mosses, crabs, crawfish and other shellfish.]

A'ia'i, Son of Kū'ula, pp. 230-254. [A'ia'i meets a young woman gathering *limu* and fishing for crabs.]

Thrum, Thomas G. (compiler). 1923. More Hawaiian Folk Tales. Chicago: A. C. McClurg & Co.

Ka'ililauokekoa, pp. 123-135. [Fresh *manini* (fish) and *Ilpoa* (*limu)* are brought for a meal in the mountains from the Pihanakalani fish pond, on Kaua'i.]

Lepe-a-Moa, The Chicken Girl of Pālama, pp. 164-170. [Lepe-a-Moa goes to the sea for fish and moss]; **Kau'ilani Finds His Sister Lepe-a-Moa**, pp. 178-184 . [Kau'ilani is told to go find Lepe-a-Moa catching squid and shellfish and gathering sea moss.] [See also the version according to Pukui and Curtis, above.]

Kai a Kahinali'i (The Hawaiian Legend of the Deluge), pp. 228-234. [A fisherman, forgetful of the gods, has no success in fishing and is angered when all he catches is a bit of coral or "an unsightly bunch of *limu* ".]

Ulu's Sacrifice (Hilo legend by Henry M. Lyman), pp. 235-241. [After the Deluge there was nothing to eat from the land, only fish and seaweeds from the ocean and a kind of reddish clay to mix with the *limu*.]

Shark Beliefs, pp. 288-292. ["All sharks have many bodies, such as crabs, *pā'ū'ū* [young *ulua*], *limu kala* [seaweed], or other forms." p. 292]

Story of Ka-'Ehu-Iki-Manō-o-Pu'uloa (The Small Blonde Shark of Pu'uloa), pp. 293-306. [The shark god Kamohoali'i is overgrown with sea moss and barnacles.]

Westervelt, W. D. 1963. Hawaiian Legends of Old Honolulu. Rutland, Vermont and Tokyo Japan: Charles E. Tuttle Company.

Legend of the Bread-Fruit Tree, pp. 28-36. [The woman gathers sea moss *(limu*). See Pukui version of this legend, above.]

Lepe-a-Moa: The Chicken Girl of Pālama, pp. 204-211; **Kau'ilani Finds His Sister Lepe-a-Moa**, pp. 220-227. [Lepe-a-Moa gathers moss from the reef. See also Thrum's version (1923, above).]

Wichman, Frederick B. 1985. Kaua'i Tales. Honolulu: Bamboo Ridge Press.

Pōhaku-o-Kāne, pp. 10-12. [The great rock brother tells his sister rock that if she stays on the reef, the red and green sea weeds will cover her.]

Kanaka-Nunui-Moe, pp. 14-16. [Wives are sent to the reef to gather seaweed for a celebration.]

Nā Piliwale, pp. 18-25. [Red seaweed is part of two fine meals.]

Ka-Lau-He'e, pp. 98-104. [A girl has to search for her own food, including seaweed.]

Ka 'Ōpele, pp. 106-111. [A man returns from sleeping in the sea for six months, seeming to have seaweed growing all over him.]

Manini-Holo, pp. 150-153. [Men gather fish, seafood, and limu from the reef at night.]

Some Traditional Hawaiian Beliefs and Practices related to *Limu*

Limu has long been a part of daily life for Hawaiians. Traditionally, different kinds of *limu* were used not only for food, but for medicine and ritual as well. Certain *limu* were considered to be some of the multiple forms, or ***kino lau***, of different gods.

Food

Hawaiians ate more different kinds of *limu* than any other people in the world, including other Polynesians. A basic Hawaiian meal would typically include two classes of foods: ***'ai*** and ***i'a***. ***'Ai*** refers to starchy food such as taro or sweet potato; ***I'a*** refers to fish or meat, but includes *limu* and salt as well. So for instance, if a family didn't have fish available, they might complement their *poi* with *limu*. Traditionally, *limu* were eaten uncooked, alone or in a mixture with other foods.

The *kapu* system forbade some people from eating certain kinds of foods. Women were forbidden to eat pork, coconut, certain kinds of bananas, and various fishes and sea creatures. They could, however, eat many kinds of shellfish and *limu*, and they became very skilled at gathering these. Most *limu* was picked at low tide by women and children. Some kinds of *limu* which grew in deeper water or at the reef edge had to be picked from canoes or by expert swimmers.

Medicine and Ritual

Traditional Hawaiian remedies made use of many different kinds of *limu* from the sea and fresh water. In preparing the remedies, *limu* was often combined with various land plants, animal substances, and minerals. These might be pounded together, baked, boiled, or dried and crushed. The mixtures were then spread or rubbed on an injury or sore, chewed, eaten, or smoked in a pipe. Various remedies involving *limu* were given for stomach ache, rashes, asthma, injuries, sores, or, very often, general weakness.

Limu had symbolic and ceremonial aspects as well. For instance, *limu kala* was one of the first foods served to a mother after she had given birth to her first child. The word *kala* means 'to loosen' or 'to remove'. The *limu kala* was given to loosen or remove any hidden diseases in the mother or in her child, who would share in the *limu kala* through the mother's milk. *Limu kala* was also used by people recovering from an illness. A person would put on a lei of *limu kala* and swim out into the ocean, allowing the water to carry the lei away--and with it, the illness.

Forms of life on the land were seen to have counterparts in the sea, and sea-life forms had land counterparts. Many of the names of life-forms reflected these relationships, for example, the *'ākala* raspberry, the *puakala* poppy, and the *limu kala* seaweed. If one of these was required for a ritual offering but was not available, another form could be used in its place.

Examples of Traditional *Limu* Management

Sometimes the Hawaiians transplanted their favorite kinds of *limu* from one island to another. For instance, *limu huluhuluwaena* was reportedly brought from Maui or Moloka'i and planted at the home of Queen Lili'uokalani in Waikīkī.

Two of the fishes most commonly raised in fishponds were *'ama'ama* (mullet) and *awa* (milkfish). These fish got most of their food from a layer of different kinds of algae and other tiny organisms which scientists call **microbenthos**. These organisms seem to grow best in the surface waters, to a depth of about two feet. The depth of coastal fishponds *(loko kuapā)* built by the Hawaiians was usually limited to two or three feet, allowing the best growth of this source of fish food. Inland freshwater ponds also included algae, such as *limu kalawai,* as fishfood. The Hawaiians maintained the pond bottoms to make good beds for the fish plants and fish food. When too much algae prevented fishnets from reaching the bottom of the ponds, they cleaned out excess.

Hawaiian Uses of Limu

ANCIENT HAWAIIANS knew, and had names for, up to perhaps 70 kinds of limu. Seven or more of these can still be found, seasonally, in Island fishmarkets.

When a Hawaiian says limu, he sometimes uses it as a general name for any plants which grow under water — fresh or salt — as well as for liverworts and lichens which grow in damp places. Even the moss which grows on rocks in fresh water streams is limu.

But, both today and in ancient Hawai'i, the word limu meant mostly edible algae gathered from either fresh or salt water.

Thus, limu means tasty seaweed.

Hawaiians relish seaweed. In the old days it was fish, poi and limu. Fish and poi supplied the protein, carbohydrates and minerals necessary for adequate nutrition.

LIMU SUPPLIED not only variety, but added some elements such as iodine and multi-vitamins.

Women, helped by the children, gathered most of the limu. They picked up what washed onto beaches or rocks and waded out at low tide to collect what floated around. They also detached limu from rocks or reef. They used a bamboo knife, a sharp stick or the edge of a shell.

Men gathered the limu from the outer reefs, from water up to 15 feet deep, and from rocks where surf pounded.

Cleaning was the job of the women.

Hawaiians didn't like grit, bits of coral rocks, small clinging sea animals, or bits of unwanted seaweeds mixed in with their limu. The women picked the wanted limu over carefully on the beach.

Then they washed the limu in sea water.

SOME VARIETIES were soaked for a day in sea water to reduce their strong iodine taste. Some varieties were soaked only in fresh water, and some varieties if soaked or washed in fresh water would wilt early and/or change flavor.

Some varieties had to be eaten the day collected. Some could be salted, wrapped in ti leaves and stored for a week or more.

But, fresh, soaked, unsoaked, or preserved, when it was time for eating limu, it was salted and usually pounded into bits. Bits could be mixed with other foods or served as a side dish.

Limu was the tasty relish which put variety into the ancient Hawaiian diet.

Hawaiians had other uses for seaweed. One variety was chopped or chewed and used for a poultice. It was frequently used on open coral cuts.

Limu was the tasty relish that put variety into the ancient Hawaiian diet.

THAT SAME variety — limu kala — symbolized spiritual purification, and the forgiveness of sin. With tumeric and limu kala mixed in sea water, a temple priest purified a family of spiritual contamination because of handling the body of a dead member.

Limu kala was eaten as part of a regular family ritual, the ho'oponopono, to lessen family tension and set its members "right" with each other.

Each summer, a priest used limu kala, with tumeric and sea water, to ritually cleanse fishermen before the season on mackerel opened.

When a lingering illness was almost over, a lei of limu kala, worn open at the bottom, was placed on the patient. The sufferer moved into the surf — away from land at all times — until the waves washed off the lei.

Any guilt or evil which caused the sickness washed off with the lei.

Another variety, limu kalawai, made love potions. What special phrases a lovelorn maiden spoke while preparing the potion have been lost. Once prepared, the girl ate some and gave some to the man she wanted.

WHILE TODAY the symbolism of Hawaiian food is almost forgotten, limu is still a part of any Hawaiian feast — the relish, often found mixed with onions and raw fish pieces for *poke*, or served alone as a side dish.

In the markets, one of the local seaweed varieties, limu manauea, is often sold under its Japanese name of *ogo*. It cooks into a good gelatine, and mixes well with octopus.

Reprinted from Pukui, Mary Wiggin. 1933. Hawaiian Folk Tales, third series. Poughkeepsie, N. Y.: Vassar College. pages 146-149.

KUKAOHIAAKALAKA

O Kukaohiaakalaka ke kaikunane a o Kauakuahine ke kaikuahine. Mai Kahiki mai laua a noho i Hawaii, o Kauakuahine i Olaa me kana kane, a o Kukaohiaakalaka i Keaau me kana wahine. Aohe keiki a Kukaohiaakalaka, a o ke kaikuahine hoi, he mau keiki no. He mahiai ka hana a ke kaikuahine i Olaa a he lawaia ka ke kaikunane i Keaau.

I kela a me keia manawa ua iho o Kauakuahine me ka ai i kahakai na ke kaikunane a o ka ia kana e hoihoi mai na kona ohana. Ua kauoha o Kukaohiaokalaka i kana wahine e haawi a nui i ka ia maloo i kona kaikuahine i na wa apau ana e iho mai ai me ka ai. Ua nana ihola ka wahine i ka i'a maloo a minamina, a hoihoi aku nei malalo o na moena e huna ai. I ka iho ana mai o Kauakuahine me ka ai, ua hala ke kaikunane i ka lawaia. Olelo aku nei ke kaikoeke, "Aohe ia a maua la. E nana ae no oe i kauhale nei, ua nele. O ka paakai wale no kahi mea i loaa." Hele no o Kauakuahine a loaa ka lipahapaha, o ko ia la hoi no ia. I ka iho hou ana mai o Kauakuahine, oia ana no, o ka hoi no me ka nele. I ahona no i kahi lipahapaha. No ka pi mau o ke kaikoeke, ua lilo ia i mea hookaumaha ia Kauakuahine. I kekahi hoi ana ana me ka lipahapaha ua manao oia he mea makehewa ka hooluhi ana iaia iho e lawe mau aku i ka ai i Keaau a o ka lipahapaha wale no ka ia e hoihoi aku ai no kane hoomanawanui ame na keiki a laua. I ke kokoke ana aku ona i ka hale o lakou ua holo maila ke kane ame na keiki e ike iaia. Ua pa'ipa'i pakahi akula oia ia lakou a lilo lakou i mau iole. O ka iole mahuahua ka makuakane ia, o na iole makalii, o na keiki no ia. No Kauakuahine ua lilo oia i punawai me ka ua kilihune e helelei ana malaila.

I ke kaikunane e lawaia ana ua hiki akula ka hoike a na akua iaia, i ke pi o ka wahine i ka i'a, a i ka lilo o ke kaikuahine i wai a o ka ohana i pua iole. Ua lilo keia i mea kaumaha i kona

KU-KA-OHIA-A-KA-LAKA[1]

Ku-the-ohia-(tree)-of-the-forest was the brother, The-sister-rain was the sister. They came from Kahiki and lived in Hawaii, the sister in O-la-a with her husband and the brother at Ke-a-a'u with his wife. The brother had no children, the sister had a flock of them. Her husband was a farmer in Olaa, the brother was a fisherman at Keaau.

The sister often brought vegetables to the shore for her brother and took back fish for her family. The brother told his wife to give his sister an abundance of dried fish when she came with the vegetables. The wife hated to give up the fish and laid it under the sleeping mats. While the husband was out fishing, the sister came with vegetables and the wife said, "We have no fish, as you can see for yourself; all we have is salt." The sister went and gathered coarse seaweed to take the place of fish. Again she came with vegetables and went back without anything. She was lucky to get the seaweed. This constant stinginess of her sister-in-law vexed the sister. It seemed to her useless to burden herself with carrying vegetables and take back in return only seaweed to her patient husband and children, and once when she came close to the house and her husband and children ran out to meet her, she gave them each a slap and changed them into rats, the husband into a large rat and the children into young rats. She herself became a spring of water where fine rain fell.

While the brother was out fishing, the gods showed him how stingy his wife had been and how his sister had become a spring of water and her family had changed into rats. He was much

1 Told to Mrs. Mary Pukui in Hilo, Hawaii, 1930.

Ku-ka-ohia-laka is one of the gods worshiped by those who go up into the forest to hew out canoes or timber for building (Malo, *Hawaiian Antiquities*, 113, 169). His image in the form of a feather god is worshiped at the time of the building of a heiau, together with Ku-nui-akea, Lono, Kane, and Kanaloa (Fornander, *Memoirs*, 6:14). His name is given as the father of Kaulu by his wife Hina-ulu-ohia at Kailua in Koolau district on Oahu (Fornander, *Memoirs*, 4:522; 5:364).

Emerson says, (Malo, 115-116 note (5)) that *laka* (*rata*) is the name of the *ohia* or *lehua* tree in Tahiti, Rarotonga, and New Zealand.

noonoo a hoi aku nei i kauhale, a ninau aku i ka wahine, "Ua haawi anei oe i i'a na na pokii o kaua?" "Ae, ka haawi mau nei no au i ka i'a." O ko Kukaohiaakalaka lalau akula no ia i na moena o ka hale o laua a hapai aela iluna. Ike aela oia i na i'a maloo ua hoonoho papaia malalo ae o ka moena, a e hoholo ae ana na puu. Ua piha loa oia i ka inaina, a i aku nei i ka wahine, "He keu oe a ka wahine lokoino. Poino kuu pokii ia oe." A me keia mau huaolelo ua pepehiia kela wahine a makeloa. Ua pii akula oia i Olaa i kahi a ke kaikuahine a ike aku nei oia i ka hoholo mai o na iole i kauhale a kulu iho nei kona waimaka aloha no ke kaikoeke ame na keiki. Hele pololei aku nei oia a ka punawai a iho iho nei ke poo ilalo iloko o ka wai a o ke kino ua lilo aela i kumu ohia.

He elua wale no pua o keia kumu ohia i na wa apau, a ke haki ka lala, kahe mai ke koko mai kona kino mai.

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distressed and returned home and asked his wife, "Did you give fish to our dear sister?" "Yes, I always give her fish." He saw the dried fish laid flat beneath the sleeping mats and what a heap of them there were. He was very angry with his wife. "What a cruel woman you are! you have brought misfortunte upon our little sister!" And with many words of reproach he beat his wife to death. He ascended to his sister's place in Olaa and saw the rats scampering about where the house had stood, and he shed tears of love for his brother-in-law and the children. He went straight to the spring, plunged in headlong, and was changed into an *ohia* tree.

Only two blossoms this tree bears to this day, and when a branch is broken off blood flows from the body of the tree.

Reprinted from Green, Laura S. (Martha Beckwith, ed.) 1928. Folk-Tales from Hawai'i. Honolulu: Hawaiian Board Room Books. pages 56-59.

HINA-I-KA-AHI A ME HINA-I-KA-WAI.

No Hilo, Hawaii, o Hinaikeahi a me Hinaikawai, a he mau wahine kupua laua. O Hinaikeahi ke kaikuaana, a o Hinaikawai no kona muli. I ke kaikuaana ka mana e hana i na mea kupaianaha me ke ahi, a i ke kaikaina hoi me ka wai. Ua mahele ia ko laua mau aina a me ko laua mau kanaka, e ko laua makuahine, e Hina.

I ka hiki ana mai o kekahi wi weliweli maluna o ka aina, ua nui ka uwe o kanaka i ka pololi. Ua nui no hoi na keiki liilii i make i ka nele o ka makuahine i ka waiu.

Nana mai nei o Hinaikeahi i kona poe kanaka, a ua hu anei ke aloha ia lakou, nolaila oia i hea mai ai ia lakou e akoakoa aku i kona alo. Kauoha aku nei oia i na kane e ahonui a e hele i ke kuahiwi i ka lapulapu wahie, a i ka muliwai i pohaku imu. A i ka ahua ana o keia mau mea, e hana i imu enaena nui. Kahaha ka naau o kanaka i ke kauoha ia i imu, oiai aohe mea ai e hoomoa aku ai. No ke aloha no i ke alii, hana kumukumu ole no.

I ka makaukau ana i ka imu, hele kaapuni anei o Hinaikeahi, a olelo iho nei, "Maanei ka uwala, ke kalo, ka uhi, ilio, puaa, ia, hapuu, a me ka moa!" Pau no kana olelo ana, hoi aku nei oia i waena o ka imu, a hea maila i kanaka e uhi iaia i ka lepo.

Uwe anei kanaka, "Aole! aole!" Olelo mai nei o Hinaikeahi, "E o'u mau kanaka, mai uwe oukou! Uhi mai ka lepo maluna o'u, a e hele ae au i na kupuna akua o kakou i ola na kakou. E nana ouhou i ke kolu o ka la, ike oukou i ke ao e kau pono ana maluna o ka imu nei. I ku he wahine me ke ano olioli ke nana aku, hu'e ia ka imu. Uhi mai ia'u!"

1 "*Hina*" is the consort of the god Ku and "*wa-hine*" is the generic name for woman or wife. There are many Hinas in Hawaiian tales and genealogies just as Ku has many manifestations.

2 In ancient days the mother's milk was the only means of nourishing a young child, hence a ritual was employed at birth to insure milk to the mother and another at the time of weaning the child. See *American Anthropologist*, XXVI, 241-245.

3 Compare the garbled story of the breadfruit tree in *Fornander Collection*, V, 676. The idea of a god's burial to provide some form of food for his people is a common convention in Hawaiian story-telling, familiar also in the South Seas.—*Ed.*

WOMAN-OF-THE-FIRE AND WOMAN-OF-THE-WATER

(As told to Mrs. Mary Pukui when she was a child, by an old lady from Hilo, Hawaii, named Kanui Kaikaina.)

There were two *kupua* women (sorceresses) living in Hilo on the island of Hawaii. Woman-of-the-fire was the elder and Woman-of-the-water was her younger sister. To the elder belonged the power to work magic with fire; to the younger, with water. Each was given her portion of land and of retainers by their mother Hina.[1]

Once famine came and great was the lamentation of the people because of hunger, and very many infants died because their mothers could not provide them with milk.[2]

As Woman-of-the-fire saw her people's distress, her compassion flowed out to them and she called them all to gather before her. Then she commanded the men to be strong and to climb the mountain after fuel and bring stones from the river in order to prepare an underground oven or *imu*, and, when everything was brought, to prepare a very hot oven. Amazement filled the men's hearts at the command to prepare an oven when there was no food to be cooked, but out of love for their chiefess they did it all without a murmur.

When the oven was ready, Hina-of-the-fire circled it, saying as she did so, "Here are potatoes, here *taro*, here yam, dog, pork, fish, the tender shoots of young fern, and here chicken!" Then she walked into the center of the oven and called to her retainers to cover her with earth.

The men wailed, "No! no!" Hina-of-the-fire spoke thus: "O my people, do not weep, but cover me over with earth. And I will go to our divine ancestors that you may have life. Watch, and on the third day you will see a cloud directly over this oven in the form of a woman with radiant face, then remove the earth. Now cover me!"[3]

Me ka hopohopo no kanaka i kanu aku ai i ke alii aloha o lakou. I ke kolu o ka la ua ike ia he ao, kohu kino wahine, maluna pono o ka imu, o ko lakou hu'e no ia i ka imu. Aohe i loaa aku o Hinaikeahi e moe mai ana, aka o na mea ai wale no ana i helu ai, o ka uhi, ke kalo, ka ia, a pela wale aku. Pau no ka lakou wehewehe ana, ike ia o Hinaikeahi e hoi mai ana mai kahakai mai, ua ohuohu i ka lei limu kala. Me ka awiwi loa i kui ia ai ka ai, a noho lakou a pau e paina. Ia lakou e ai ana, hai mai o Hinaikeahi i kona hele ana i na kupuna ahi e aloha mai ia lakou. A i ka piha ana o kana imu i ka ai, ua hele oia i ka auau kai me Hinaopuhalakoa.

E like no me ke ano maa mau o kanaka o ka walaau, ua ohiohi aku nei ko Hinaikeahi mau kanaka i ka Hinaikawai i ka ono maoli o na mea ai a ka haku o lakou i hoolako ai! Hoi aku nei ko Hinaikawai mau kanaka, a uwe aku nei i ke alii o lakou, me ka hoike pu aku nohoi i na mea a pau a lakou i lohe mai ai mai na kanaka o Hinaikeahi mai. Komo iho nei ka manao lili iloko o Hinaikawai. Kauoha aku nei oia i na kanaka e hana i imu nui, a i ka makaukau ana, ua hoohalike oia me ka kona kaikuaana i ka helupapa i na mea ai; a pau ia, hea aku nei i na kanaka e uhi iaia i ka lepo.

I ke kolu o ka la, he la umamalu ia, ua ike ia he ao uliuli, me he wahine la, e kau pono ana maluna o ka imu. Me ka eleu loa na kanaka i hu'e ai i ka imu. Auwe! aohe ai i loaa aku, aka o ke kino papaa wale no o Hinaikawai! I ka hamama ana o ka imu, ua hoohelelei ka ua, a ua olelo ia, o na waimaka ia mai ka lani mai no Hinaikawai. Ina ua kii no o Hinaikawai i kona mahele, he wai, ina no ia i ola. Aole nae, pii koke ka lili, a lele kamoko i ka mana o ke kaikuaana. O ka hopena ia o ka hookiekie. Ike anei na kanaka, aohe a lakou haku, aohe mea ai, o ke hoi no ia a pau me Hinaikeahi.

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With great reluctance the men did as their beloved chiefess commanded them. On the third day a cloud in the shape of a woman appeared directly over the oven and immediately the men uncovered it. There was no body lying there, but the foods she had enumerated were there—yam, *taro*, fish, and all the rest And after the oven had been opened, Hina-of-the-fire appeared coming from the direction of the sea-coast wreathed with brown sea-weed. In haste was the food served and all were seated at the feast while Hina-of-the-fire related the story of her visit to her divine ancestors who had thus shown their love for her. After eating, she went sea-bathing with Hina-opu-hala-koa, the "Woman-of-the-coral," who was one of the wives of the god Ku.[4]

According to the custom of mankind, this occurrence caused much talk, and the retainers of Woman-of-the-fire boasted about the delicious food provided by their mistress. The followers of Woman-of-the-water therefore complained before her, reporting what they had heard from the retainers of Woman-of-the-fire. Thus the spirit of jealousy entered into Woman-of-the-water, and she commanded her retainers also to prepare a great oven, and when this was done she imitated her older sister by repeating the names of various foods and then calling upon her retainers to cover her with earth.

The third day the sky was overcast and a dark cloud in the form of a woman stood directly over the *imu*. The men made haste to remove the covering. Alas! no food was visible, only the charred body of Woman-of-the-water burned to a crisp. The rain began to fall after the oven was opened, and it was said that this was the weeping of heaven over Woman-of-the-water. If she had only used her own gift of water she would have been saved alive, but not so! she was jealous and flew to usurp the magic gift of her older sister, hence the penalty of her pride. When her retainers saw that they had neither chiefess nor food, they all went to live with Woman-of-the-fire.

[4] Something seems to be lost out here, for this goddess must have returned with Hina from her visit to her ancestors. Sea-bathing is a purification ritual and hence the episode probably belongs before rather than after the feast. Cf. the ceremonial bathing of Lohiau after his restoration to life in the Pe-le legend.—*Ed.*

E. Limu Metaphors

Subject Areas: Language Arts
Hawaiian Language
Hawaiian Studies

Key Concept:

Limu is one of the natural images used in Hawaiian *ʻōlelo noʻeau* ('wise sayings, proverbs') to refer metaphorically to natural, social or individual conditions.

Activity Objectives:

Students will read and become familiar with some forms of Hawaiian *ʻōlelo noʻeau.*
Students will be able to recognize metaphorical references which use *limu* as an image.
Students will be able to create metaphorical sayings about *limu.*

Skills Emphasis: reading comprehension (English, Hawaiian)
recognizing and using metaphoric and poetic forms of expression

Vocabulary:

ʻōlelo noʻeau	metaphor	*kaona*

Resources:

Mary Kawena Pukui. 1983. *ʻŌlelo Noʻeau:* Hawaiian Proverbs & Poetical Sayings. Honolulu : Bishop Museum Press (Special Publication No. 71). [See Preface, pp. vii-ix.]

Materials and Equipment:

one copy of the *ʻōlelo noʻeau* pages (E5-E9), cut into strips [see Procedures, step 1]
copies of the *ʻōlelo noʻeau* pages for each student
Pukui, Mary Kawena and Samuel H. Elbert. 1986. Hawaiian Dictionary. Honolulu: University of Hawai'i Press.

Time Needed: two class periods, with homework assignment in between

Management Suggestions:

In Hawaiian language classes, these *ʻōlelo noʻeau* can be used for exercises in reading aloud, translating, or studying different grammatical structures. If students do not read Hawaiian, they might still enjoy translating some of the Hawaiian words, using a Hawaiian Dictionary.

Background:

What Are *'ōlelo No'eau* ?

In Pukui and Elbert's Hawaiian Dictionary, ***'ōlelo no'eau*** is translated as 'proverb, wise saying, traditional saying'. In the introduction to Mrs. Pukui's 1983 collection, the editors note that these sayings might "be categorized, in Western terms, as proverbs, aphorisms, didactic adages, jokes, riddles, epithets, lines from chants, etc., and they present a variety of literary techniques such as metaphor, analogy, allegory, personification, irony, pun, and repetition." (Preface, p.vii.)

The editors point out, however, than the meanings and purposes of these spoken sayings should not be assessed by the Western concepts of literary types and techniques. Hawaiian poetical expression involves ambiguity, reference to unnamed concepts, and multiple, hidden meanings ***(kaona)*** and connotations. Therefore, not all meanings of the *'ōlelo no'eau* in Mrs. Pukui's book are expressed in the English translations and notes.

While not subjecting *'ōlelo no'eau* to a strict literary analysis, students can still begin to appreciate these sayings by recognizing instances of metaphorical speech. A **metaphor** is a figure of speech containing an implied comparison, in which a word or phrase ordinarily and primarily used with one thing is applied to another. The purpose of this module is for students to recognize a variety of ways in which *limu* characteristics are used metaphorically in *'ōlelo no'eau* to refer to natural, social, or individual conditions or qualities.

Limu Metaphors and References in *'ōlelo No'eau*

The sayings included here can serve to give an idea of what characteristics of *limu* were commonly recognized by Hawaiians in the past, and some of the ways these characteristics were used as metaphors by them. The characteristics include the fragrance and appearance of *limu*, its slipperiness, its flexibility, the way it breaks off and drifts ashore, and the way it floats.

Some of the sayings employ *limu* characteristics as metaphors for personal qualities (e.g. Nos. 971, 2011) or compare natural with social conditions (e.g. No. 118). Others refer to human activities: the ease with which women pick *limu* is compared to their falling in love with a man (No. 2001); a trickster in a legend stuffs *limu* into a lobster shell to fool his future father-in-law (979); and drowned *kauā* (slaves, outcasts) floated like *limu* at Kualoa, O'ahu (No. 1443).

Some of these sayings seem to use "fish" *(i'a)* as a metaphor for *limu* (Nos. 1332, 1362, and 1368; see also the riddle from Judd's collection which is used as the frontspiece for this book). These might also be using the term *i'a*, not so much as fish literally, but as the category of food that is eaten as a relish with a staple starch*('ai)*. A typical meal includes both *'ai* and *i'a*. Thus, with *poi* for instance, one might eat meat, fish, seaweed or a leafy land vegetable, or even salt, any of which could serve as *i'a*.

Other sayings seem simply to mention particular places noteworthy for the *limu* there (Nos. 1446, 1442, 2255). On the surface, these seem to be simply statements about qualities of *limu*, but they may have other meanings as well. Although subtle connotations may be beyond those of us who are not native speakers of Hawaiian, or who are thoroughly steeped in Hawaiian culture and history, it is important to acknowledge the possibility of their existence.

After studying these *'ōlelo no'eau*, students are asked to reflect on their own experiences, and to create metaphorical expressions using some characteristics of *limu* which have impressed them.

Procedures:

1. Duplicate one set of the thirteen *ʻōlelo noʻeau* (pages E5-E9). Cut it into strips, each strip having either a saying (in Hawaiian and English) **or** an interpretation (printed in plain italics). Distribute the strips of paper to the students. Each student should circulate to find the person who has the sayings or the interpretation to match what is written on his or her own strip. Most matches will be relatively easy, due to the presence of clues such as names of people, places, or particular *limu*. The others can be matched by process of elimination. This initial interaction can serve to introduce the students to the *ōlelo noʻeau*.

2. Hand out copies of the sheets with all thirteen *ʻōlelo noʻeau* to each student, and ask them to read them over. Students could work in small groups to make lists of :

(a) what characteristics of *limu* are included in these sayings, and

(b) how these characteristics are being used as metaphors, that is, what comparisons are apparently implied. If none are obvious, note any other kinds of references made.

For instance:

ʻŌLELO NOʻEAU:	**CHARACTERISTIC:**	**METAPHOR (or other reference):**
118	fragrance	sign of something happening in one place being noticed in another
971	breaking off and drifting ashore	person who drifts
979	found in shellfish	when stuffed in an empty shell, a bad trick
1332	fragrance	fish/food eaten as a relish with a staple
1443	floats	drowned people
1446	fragrance	noted at Kalauonaona in Puna, Hawaiʻi

Note: Remind students that these apparent meanings may not be the only possible interpretations.

3. Ask for representatives of each small group to contribute their lists to a master list, to be compiled on the blackboard.

4. Ask students to think about any other characteristics of *limu* they may have noticed (e.g. taste, crunchiness, how or where it grows, how it is valued). Write their suggestions on the board.

5. Homework assignment: Using one or more characteristic of *limu* , create a metaphorical saying, something like an *ʻōlelo noʻeau* . For instance, the sayings can refer to personal qualities, places with noteworthy *limu*, or compare natural and social conditions. Students could model their sayings after the forms of the *ʻōlelo noʻeau* included in this unit.

6. Next class period, ask students to read their sayings, and discuss with the students how they used the characteristics they selected to make metaphoric statements about other things.

Nā ʻŌlelo Noʻeau e pili ana i ka Limu
(Proverbs about Seaweed)

Excerpted with permission from *ʻŌlelo Noʻeau:* Hawaiian Proverbs & Poetical Sayings, collected, translated, and annotated by Mary Kawena Pukui. Honolulu 1983: Bishop Museum Press (Special Publication No. 71).

118: *ʻAno kaikoʻo lalo o Kealahula, ua puhia ke ʻala ma Puahinahina.*

It is somewhat rough down at Kealahula, for the fragrance [of seaweed] is being wafted hither from the direction of Puahinahina.

There is a disturbance over there, and we are noticing signs of it here. The breeze carries the smell of seaweed when the water is rough. [p. 15]

971: *He wahi limu pae.*

Seaweed washed ashore.

An insignificant person who, like the seaweed, merely drifts. [p.104]

979: *Hewa ka iʻa a ʻUmiamaka, he okea loko.*

Wrong was the "fish" of ʻUmiamaka for it had sand inside.

Said of anything that is bad, or when one has been cheated.

ʻUmiamaka was a young trickster who desired the daughter of a certain man who was very fond of lobster. But the father would not let his daughter go with a man who was not a fisherman. To win the father over ʻUmiamaka filled a lobster shell he found on the beach with white sand. After stuffing the crack carefully with limu so it would appear freshly caught, he presented it to the father. After receiving the lobster, the father allowed his daughter to go out with ʻUmiamaka. But when the man gave his attention to the lobster, he discovered that it was just a sand-filled shell, and cried out these words. When the impudent youth returned, he claimed innocence, saying, "That was your fish, not mine." [p. 105]

1332: *Ka i'a hanu 'ala o kahakai.*

The fragrant-breathed fish of the beach.

The Līpoa, a seaweed with an odor easily detected from a distance. [p. 145]

1362: *Ka i'a lauoho loloa o ke kai.*

The long-haired fish of the sea.

Limu, or seaweed. [p. 148]

1368: *Ka i'a māewa i ke kai.*

The fish that sways in the sea.

The limu (seaweed), which sways with the movement of the sea. [p. 149]

1442: *Ka limu kā kanaka o Manu'akepa.*

The man-throwing algae of Manu'akepa.

Hanalei, Kaua'i, was known for its pouring rain. A slippery algae grows among the grasses on the beach, and when carelessly stepped on, it can cause one to slip and fall. This algae is famed in songs and chants of that locality. [p. 156] [Manu'akepa is a land section in Hanalei. The scientific name of this slimy blue-green algae is *Nostoc commune*.]

1443: *Ka limu lana o Kawahine.*

The floating seaweed of Kawahine.

A term applied to the kauwā who were drowned at Kualoa, O'ahu before serving as sacrifices. [p. 156]

1446: *Ka Līpoa 'ala o Kalauonaona.*

The fragrant *Līpoa* seaweed of Kalauonaona.

The most fragrant Līpoa seaweed in Puna, Hawai'i, is found at Kalauonaona (also known as Kalauonaone) in Kaimū. [p. 156-7]

2001: *Like no lāua me Limunui.*

He is like Limunui.

Women fall in love with him as easily as gathering limu (seaweed). This was said of Kahalai'a, a chief who was very handsome and kind. [p. 216]

2011: *Limu pahapaha nolu i ke kai.*

Sea lettuce, easily swayed by the action of the tide.

A derogatory expression for a person weak of character or physical ability. [p. 217]

2255: *Na Līpoa 'ala o Kawehewehe.*

The fragrant *Līpoa* of Kawehewehe.

The Līpoa seaweed of Waikiki, especially at Kawehewehe, was so fragrant that one could smell it while standing on the shore. Often mentioned in songs about Waikiki. [p. 246]

2734: *Puleileho ke kai o Ka'elo.*

A rough sea in the month of Ka'elo.

When the seaweed breaks loose and is borne shoreward, fish that feed on it are drawn there. So a rough sea can be good for the fishermen. [p. 300]

F. "Get *Limu*?": *Limu* in Hawai'i's Economy

Subject Areas: Language Arts
Home Economics
Economics
Mathematics

Key Concept:

Despite a marked decline in the quantities of *limu* picked and sold in Hawai'i in the past decade, consumer demand now appears to be increasing, and prices are on the rise.

Activity Objectives:

Students will be able to conduct research to find out amounts, kinds and prices of *limu* being picked or sold in their areas.

Students will be able to analyze research findings, compare them with other data, and draw conclusions about trends over time.

Skills Emphasis:

reading and interpreting a chart
hypothesizing causes
interviewing
converting and comparing quantities and prices
computing totals, averages, and percentages

Materials and Equipment:

for each student:

a copy of the chart, **Quantities of *Limu* Harvested and Sold, 1977-1984** (F7)
a copy of the chart,**1976 *Limu* Prices and Packaging Information** (F9)
a copy of the **Research Instructions** on one of three topics (F11-F15)

for each small group of four to six students:

a copy of the **Research Topic Discussion Questions** (F17, F21, F 25) for their topic
a copy of the **Research Topic Worksheet** (F 19, F 23, F 27) for their topic
a copy of the **Summary Discussion Questions** (F 29)

Time needed: minimum of two class periods plus student field research time

Background:

LIMU PRICES AND PACKAGING, 1976

According to Heather Fortner's 1979 book The Limu Eater, there were ten kinds of *limu* sold in Hawai'i's fish markets and large grocery stores in 1976. These are available fresh, salted, or in other preparations. Fortner summarizes this information along with the 1976 retail market prices for *limu* in a chart, reprinted here (page F9) with the publisher's permission.

QUANTITIES OF *LIMU* HARVESTED AND SOLD, 1976-1984

In her 1979 article, "The Uses of Seaweed as Food in Hawai'i," Dr. Isabella Abbott discusses prices and quantities of both Hawai'i-grown *limu* and imported seaweeds sold in 1976. [This article is reprinted in this book; see Module H, pages H11-H17.] She cites 1976 state government figures showing that approximately 80,000 pounds of two species of *Gracilaria (Limu manauea,* or *ogo)* were sold that year. Dr. Abbott estimates that this figure is about three times the quantity of all other Hawai'i-grown *limu* sold in 1976. In other words, perhaps another 26,000 pounds of other kinds of *limu* were sold, or a total of more than 100,000 pounds that year. Dr. Abbott also estimates that another 80,000 pounds of seaweed were harvested annually for personal use.

The annual figures available from the State Department of Land and Natural Resources, Aquatic Division show a dramatic decline in commercial *limu* harvesting since that time, with a low of around 5,000 pounds reached in 1982. (See the chart, page F7.) Since that time, the commercial harvest has increased, with the 1984 total poundage approaching the 1979 level, but still remaining far below the 1976 and 1977 figures.

[Note: The DLNR reports prior to 1986 group all species of *limu* together. DLNR Research Statistician June Shimana estimates that *Gracilaria* represents 80% of the total sold each year.]

QUANTITIES DROP, PRICES RISE

At the same time, the dollar value of the pounds of *limu* sold has increased overall. Interestingly, while the amount of *limu* available for sale dropped markedly, the price almost quadrupled between 1977 and 1982. As quantities available for sale began to rise, the price dropped back to approximately the 1980 level. The chart on page F7, **Quantities of *Limu* Harvested and Sold, 1977-1984**, provides a classic illustration of the interaction between supply and demand.

WHY THE DECREASE IN *LIMU* HARVEST?

A number of factors might be involved in the dramatic decrease in the annual quantities of *limu* reported as harvested for commercial sale, and sold, as reflected in the DLNR reports since 1976. One factor could be **under-reporting**, but this is not likely to be a major cause for a decrease of such magnitude. Two other categories of causes should be considered:

1. **Environmental change,** such as a **decrease in available nutrients** or **siltation.**

a) Sewage, including human waste, is one source of nutrients for *limu*. (See Module C, *Limu* Habitat Field Study.) Because of concern about pollution in our inshore waters, however, the sewage outfall in places such as Kailua Bay and at Sand Island have been relocated to deeper water in

recent years. This change coincides with the decrease in the quantity of *limu* reported as harvested (which is likely to be closely related to the amount growing). Henry Okamoto, Fisheries Biologist for the Aquatic Division of the Hawai'i State Department of Land and Natural Resources, suggests that the decrease in the discharge of sewage in inshore waters explains much of the recent decline in the availability of one kind of *ogo*.

b) **Siltation** of inshore areas is another environmental change which could be affecting *limu* habitats. Silt carried to the sea from inland may cover the *limu* in an area, shutting out sunlight, or cover the bottom, providing a soft and shifting surface unsuitable for *limu* attachment. Dr. Isabella Abbott estimates that perhaps 10% of the present decline in the availability of *Gracilaria* can be attributed to siltation.

Both of these examples of environmental change might also be seen as caused by **indirect human action.** In the first case, the trade-off is between clean inshore waters or plenty of *limu*. The second case is an instance of upland activities contributing to erosion and runoff, causing unintended impact at the shore.

2. **Direct human action,** such as **overharvesting,** or **incorrect harvesting** (e.g. pulling *limu* out by the holdfast instead of cutting the stipe). Dr. Isabella Abbott estimates that overpicking is 90% responsible for the present decline in the availability of *Gracilaria* . "*Ogo* is in short supply because everybody likes it." (See Module G, *Limu* Conservation.)

A NEW SOURCE OF SUPPLY: *LIMU* AQUACULTURE

A number of wholesalers and retail groceries in Hawai'i now buy *ogo* which is cultured in a seaweed farm. Hawaiian Marine Enterprises on the North Shore of O'ahu at Kahuku cultivates three varieties of *Gracilaria*--two colors of *G. coronopifolia (Limu manauea/ogo)* and another, as yet unidentified *Gracilaria* species. According to Dr. Rick Spencer at HMC, they sell approximately 1500 pounds a week of these *limu*, for about two dollars a pound, bulk rate. They are in the proces of expanding production.

This operation began in May 1984 after a year of research and development of the culture system. The *limu* is grown outdoors in semi-cylindrical tanks above ground, that is, the *limu* are not attached to anything. The growers supply the nutrients (nitrogen, phosphorus, extra carbon and trace elements) and control contamination. The *limu* are harvested with scoop nets, and do not have to be cleaned of sand and animals before being sold.

OVERVIEW OF MODULE

This module involves students in conducting field research, interviewing both *limu* pickers and grocers in markets where Hawai'i-grown *limu* and imported seaweeds are sold. The students can gather information about estimated quantities gathered and/or sold, current prices, and estimates of recent trends in both quantities and prices.

This raw data, along with the information provided in this module, can be analyzed in a number of ways. For instance:

- Students can compare price information from different markets, and compute current average prices for different types of local and imported seaweeds. An average price for local *limu* in general can be computed and compared with the long-term information from DLNR.

- Students can compare price/pound received by *limu* pickers with the retail sale prices, and compute the percentage of mark-up.

- Students can compare information from their interviews about long-term trends in quantities and prices of *limu* with the DLNR data, and look for clues to explain the fluctuation in amounts of *limu* harvested commercially over the past decade.

The **Research Instructions, Reseach Topic Discussion** questions and worksheets, and **Summary Discussion Questions** in the following pages are offered to illustrate some of the possible directions this research could take. Don't allow these suggestions to limit your students' explorations! Modify them as needed to accommodate student interests and the information they gather.

Management Suggestions:

Ideally, the class would be divided more or less equally among the three research topics, to provide a range of information on each topic. Students could work alone or in pairs to conduct their market research at different markets. Students who have relatives or close friends who pick *limu* would be the most appropriate to do the research about *limu* picking.

Small groups of students can work together to compare research findings within topics, and to compute and prepare answers to the summary discussion questions. The size of the groups should be kept to six students or fewer, in order to encourage all to participate.

Resources:

1. Abbott, Isabella. 1979. The Uses of Seaweed as Food in Hawai'i. Economic Botany 32(4) 409-412.
2. Fortner, Heather. 1979. The Limu Eater. Honolulu: University of Hawai'i Sea Grant College Program.
3. State of Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources (formerly Fish and Game). Commercial Fish Landings for Calendar Year.

Extension:

Invite students to search grocery store shelves for other products which have seaweed ingredients, such as alginate (from kelp, or from *Sargassum*), agar (from *Gelidium*, or from *Gracilaria*), or carageenan (from *Eucheuma*). Student teams could compete to see who compiles the longest list of products. To get them started, suggest they look at labels on some of the following items:

shampoo	salad dressing	yogurt
toothpaste	chocolate milk	canned milk

In health food stores, students might also find the food supplement *Spirulina*. Currently this blue-green microalga is being cultivated by Cyanotech Corporation at the Natural Energy Laboratory of Hawai'i on the Big Island. At least four other companies in Hawai'i are planning to start *Spirulina* production in the near future. Another algae-based food supplement to look for is beta carotene, shown in recent studies to help prevent cancer. The microalga *Dunaliella* is a rich source of beta carotene, and is also under production by Cyanotech.

Procedures:

1. Hand out the chart, **Quantities of *Limu* Harvested and Sold, 1977-1984.**

2. Ask students what **trends they observe** taking place over this eight year time period. That is, what increases or decreases **in quantities of *limu* caught or sold**, and the **dollar value** of the *limu* sold, do they observe? For instance:

- The quantity of *limu* caught for commercial sale has decreased dramatically since 1977, and only begun to increase since 1982.*

- The total dollar value of *limu* sold has decreased every year except 1981 and 1984.

*You could also give students the information from Dr. Abbott's article about 1976 quantities.

By dividing annual dollar value by quantities sold (or harvested, in 1977), students can also get a picture of **average price/pound.**

- The average price/pound for *limu* almost quadrupled between 1977 and 1982, and then declined such that the 1984 price was close to that of 1980.

3. Ask students to **hypothesize causes** for these trends. Discuss with them the impacts of decreasing nutrient sources by moving sewage outfalls; siltation of inshore areas as a result of upland activity; and overharvesting. How might trends in quantities, total dollar value of harvest, and prices be related? (Dollar value of harvest tends to drop as quantities decline, offset to some extent by the increased price as demand exceeds supply.)

4. Ask students to choose one of three topics to research in their local area.

Topic A: **Hawai'i-grown *Limu* in Local Markets**
Topic B: **Imported Seaweeds in Local Markets**
Topic C: **Picking *Limu***

Hand out the **Research Instructions** for the topics they choose. Set a date by which they should have completed their research, and bring their findings to class.

5. When students have obtained the information on their topics, ask them to work in small groups with other students who have conducted research on the same topic. Hand out the **Research Topic Discussion Questions** and **Worksheets** to help them summarize their findings. Note: For easier reference by the whole class during the summary discussion, small groups could use the worksheet format to record their information on large sheets of newsprint.

6. Ask each small group to present their findings to the class. Each member of a small group can report briefly on one or two of the questions the small group addressed. Ask the other students to listen carefully and note especially for each kind of *limu* or seaweed: the price per pound, the amount sold, and how packaged or prepared for sale.

7. When all the reports have been given, hand out copies of the **Summary Discussion Questions** and copies of the Fortner's 1979 chart,**1976 *Limu* Prices and Packaging Information**, or copy Fortner's information onto the blackboard. The students will need this information, along with the research information from all the topics, to answer the discussion questions. Allow students some time to prepare, then discuss the questions with the whole group.

Quantities of *LIMU* Harvested and Sold, 1977-1984

Year	Pounds Harvested	Pounds Sold	Dollar Value of Pounds Sold
1977	92,285	- - - - - *	$58,991
1978	44,707	44,664	31,353
1979	17,025	16,679	19,870
1980	10,566	10,254	16,072
1981	9,007	8,941	18,861
1982	5,581	5,568	14,182
1983	7,131	6,990	13,382
1984	15,770	15,229	24,789

* Figures not available

Source: State of Hawai'i Department of Land and Natural Resources, Aquatic Division. Commercial Fish Landings for Calendar Year. (Reports for 1977 through 1984)

1976 *Limu* Prices and Packaging Information

Limu	How Sold	Price*
Limu kohu (*Asparagopsis taxiformis*)	Salted, in containers	$4.50 to $9.00/lb
	Packed into small balls	$ .40 to $1.50/ea
Limu wāwae'iole (*Codium* spp.)	Fresh, in open bins or in plastic bags	$ .79 to $1.29/lb
	Salted and wilted, in containers	$2.00 to $3.00/lb
Limu 'ele'ele (*Enteromorpha* spp.)	Salted, in small plastic containers	$2.09 to $3.59/lb
Limu manauea – ogo (*Gracilaria* spp.)	Fresh, in open bins or packaged in plastic bags	$1.10 to $1.59/lb
	Salted and chopped in small container, for addition to poke	$1.50 to $2.70/lb
	Prepared kim chee	$1.99/lb
	Prepared namasu	$1.59 to $1.99/lb
Ararucip (*Caulerpa racemosa*)	Fresh, in open bins	$ .89 to $1.19/lb
Limu lipoa (*Dictyopteris* spp.)	Salted, packed in jars	$3.79 to $4.75/lb
Tambalang – guso (*Eucheuma spinosum*)†	Fresh, in open bins	$ .79 to $ .99/lb
Limu huluhuluwaena (*Grateloupia filicina*)	Salted, in small plastic containers	$2.00 to $3.00/lb
Sea lettuce – Limu lepe 'ula'ula (*Halymenia formosa*)	Fresh, in open bins	$1.25/lb

*1976 prices
†1976 data; not available at present

Reprinted with permission, from The Limu Eater by Heather Fortner. Honolulu: University of Hawai'i Sea Grant College Program, 1978. p. 38.

Research Instructions

Topic A: Hawai'i-grown *Limu* in Local Markets

Choose two or more markets in your area. When you go to conduct your research, ask to speak to the grocer, the manager, or the person in charge of the seafood department. Explain that you are doing a school assignment about seaweeds in Hawai'i, and get permission to ask him or her some questions.

Find out the following about the **Hawai'i-grown *limu* sold** in two or more markets in your area:

1. **Varieties:** Which kinds of *limu* are usually for sale?

2. **How sold:** How are each of these packaged or prepared for sale?

3. **Sources:** Where do the stores get their supplies of each kind of *limu*?

4. **Current prices** for each kind of *limu*. (**Note:** If not given as price per pound, then convert to price per pound for comparison with other prices. Remember: 16 ounces = l pound; 28 grams = 1 ounce.)

5. **Price trends:**
   a) Do these prices go up and down throughout the year?

   b) Overall, have the different *limu* become cheaper or more expensive to buy in recent years?

6. **Quantities sold:**
   a) Ask the grocer to estimate how much of each kind is sold. (If this amount is given in terms of a quantity per week or month, convert it to **pounds per year** for comparison in class.)

   b) Over the past eight to ten years, have the overall quantities of *limu* sold each year decreased or increased?

7. **Explanation for trends:**
   Does the grocer have an opinion about why the quantities and prices of *limu* have changed as they have, (or remained the same)? What is his or her explanation?

Research Instructions

Topic B: Imported Seaweeds in Local Markets

Choose two or more markets in your area. For this topic, try supermarkets and grocery stores, especially Asian markets. When you go to conduct your research, ask to speak to the grocer, or the manager. Explain that you are doing a school assignment about seaweeds in Hawai'i, and get his or her permission to ask some questions.

Find out the following about the **imported seaweed sold** in two or more markets in your area:

1. **Varieties:** What kinds of seaweed are imported for sale in Hawai'i from elsewhere?

2. **How sold:** How are they each packaged or prepared for sale?

3. **Sources:** Where are they each from?

4. **Current prices** for each kind of seaweed. (Note: If not given as price per pound, then convert to price per pound for comparison with other prices. Remember: 16 ounces = I pound; 28 grams = 1 ounce.)

5. **Price trends:**
   a) Do these prices go up and down throughout the year?

   b) Overall, have the different seaweeds become cheaper or more expensive to buy in recent years?

6. **Quantities sold:**
   a) Ask the grocer to estimate how much of each kind is sold. (If this amount is given in terms of a quantity per week or month, convert it to **pounds per year** for comparison in class.)

   b) Over the past eight to ten years, have the overall quantities of imported seaweed sold each year decreased or increased?

7. **Explanation for trends:**
   Does the grocer have an opinion about why the quantities and prices of seaweed have changed as they have, (or remained the same)? What is his or her explanation?

Research Instructions

Topic C: Picking *Limu*

Find out the following about the kinds of ***limu* picked** by two or more *limu* pickers you know:

1. **Varieties:** What kinds of *limu* do you usually pick?*

2. **Personal use, or commercial:** Do you usually pick *limu* for your own use and for family and friends, or do you sell it to markets?

3. **Personal quantities:** If the person picks *limu* for self, family and friends, ask:

   a. About how much of each kind of *limu* do you pick in a week (or a month)?
   b. Can you find each kind year round? If so, do you pick about the same amount every month?
   (Use this information to estimate how much the person picks of each kind of *limu* in a year. Convert the amount to **pounds per year**.)

4. **Commercial quantities and prices:** If the person sells the *limu* they pick, ask:

   a. How many pounds do you estimate you sell in a week (or a month)? Do you pick *limu* year round? If not, about how many months a year do you usually pick and sell *limu*?
   (Use this information to estimate **how many pounds** the person **sells in a year**.)

   b. What **price per pound** do you get for each kind of *limu*? Does this price stay the same throughout the year? Has it gone up or down in recent years?

5. **Quantities over time:** Have the quantitites of *limu* you've picked over the past few years increased or decreased? If so, what do you think might be causing the increase or decrease?

*** Note:** The *limu* pickers you talk to may use different names for the *limu* they pick than the ones you know. Ideally, you should try to talk to them at the place they pick, so you can see the kinds they're talking about. Write down the names they use and try to match them with the names you know.

Research Topic Discussion

Topic A: Hawai'i-grown *Limu* in Local Markets

1. Compare the information you obtained with the information gathered by the other students in your small group to answer these questions. Note any **differences** in your findings, for instance:

-**kinds** of *limu* available in some stores and not in others

-differences in the **packaging or preparation** of various *limu*

-different **sources** of *limu* supply for the various stores

-the range of **prices** per pound for the different kinds of *limu*

-the **quantities** of each kind sold in different stores (convert to pounds per year to compare)

2. Summarize your findings on the Research Topic Worksheet, or on a large piece of newsprint, using a format similar to the worksheet.

a. What **kinds of Hawai'i-grown *limu*** are sold in the stores you studied? In the first column, list all the kinds of *limu* you found being sold.

b. **How** are each of these **packaged or prepared for sale**? Is any one kind sold in more than one way? In the second column, next to the name of the *limu*, write the ways each kind are being sold.

c. In the third column, write the **sources of supply** for each kind of *limu* for all the stores.

d. Make sure all prices are expressed as **price per pound**. Then for each kind of *limu*, compute the **average** price per pound you found in the stores studied. In the fourth column, write this average, along with the **range** (the lowest and highest price) found.

e. Compare the information provided by the different grocers concerning the estimated quantities sold for each kind of *limu*. (Make sure all quantities are expressed in pounds per year, first.) Then compute a **total quantities sold**, for **each kind** of *limu*, for all the stores studied. Note this total in the last column on the worksheet or newsprint.

At the bottom of this column, compute the **total quantities** for **all** kinds of *limu* **combined**.

f. Compare the information provided by the different grocers about *limu* **price trends**. Did they report a seasonal change in the price for any kinds of *limu* within the year? Did they report a general price increase or decrease for any kinds over the past few years? Note these changes or trends on the worksheet or newsprint.

g. Compare the opinions expressed by the different grocers about **trends in the quantities of *limu* sold**. Note these opinions on the worksheet or newsprint.

Research Topic Worksheet
Hawai'i-grown *Limu* in Local Markets

a. Kinds of Hawai'i-grown *Limu*	b. How Sold	c. Sources	d. Price per Pound (average/range)	e. Total Quantities Sold (lbs./year)
				Combined Total

f. Price changes within the year:

Price changes over the past few years:

g. Explanations for changes in quantities sold:

Research Topic Discussion

Topic B: Imported Seaweeds in Local Markets

1. Compare the information you obtained with the information gathered by the other students in your small group to answer these questions. Note any **differences** in your findings, for instance:

-**kinds** of imported seaweeds available in some stores and not in others

-differences in the **packages or preparation** of various seaweeds

-different **sources** of seaweed supply for the various stores

-the range of **prices** per pound for the different kinds of seaweed

-the **quantities** of each kind sold in different stores (convert to pounds per year to compare)

2. Summarize your findings on the Research Topic Worksheet, or on a large piece of newsprint, using a format similar to the worksheet.

a. What **kinds of imported seaweed** are sold in the stores you studied? In the first column, list all the kinds of imported seaweeds you found being sold.

b. **How** are each of these **packaged or prepared** for sale? Is any one kind sold in more than one way? Write in the second column, next to the name of the seaweed, the ways each are being sold.

c. In the third column, write the **sources of supply** for each kind of seaweed for all the stores.

d. Make sure all prices are expressed as **price per pound**. Then for each kind of seaweed, compute the **average** price per pound you found in the stores studied. In the fourth column, write this average, along with the **range** (the lowest and highest price) found.

e. Compare the information provided by the different grocers concerning the estimated quantities sold for each kind of seaweed. (Make sure all quantities are expressed in pounds per year, first.) Then compute a **total quantities sold**, for **each kind** of seaweed, for all the stores studied. Note this total in the last column on the worksheet or newsprint.

At the bottom of this column, compute the **total quantities** for **all** kinds of imported seaweed **combined**.

f. Compare the information provided by the different grocers about seaweed **price trends**. Did they report a seasonal change in the price for any kinds of seaweed within the year? Did they report a general price increase or decrease for any kinds over the past few years? Note these changes or trends on the worksheet or newsprint.

g. Compare the opinions expressed by the different grocers about **trends in the quantities of imported seaweeds sold**. Note these opinions on the worksheet or newsprint.

Research Topic Worksheet
Imported Seaweeds in Local Markets

a. Kinds of Imported Seaweed	b. How Sold	c. Sources	d. Price per Pound (average/range)	e. Total Quantities Sold (lbs./year)
				Combined Total

f. Price changes within the year:

Price changes over the past few years:

g. Explanations for changes in quantities sold:

Research Topic Discussion

Topic C: Picking *Limu*

1. Compare the information you obtained from your interviews with *limu* pickers with the information gathered by other students in your small group.

2. Summarize your findings on the Research Topic Worksheet, or on a large piece of newsprint, using the same format as the worksheet.

a. What kinds of *limu* are picked by the people you interviewed? In the first column, list the **names** of all of these kinds of *limu*.*

b. Do the people you interviewed pick these *limu* for their personal use (self, family and friends) or do they pick to sell to markets? In the second column, across from the name of the kind of *limu*, write **"personal use"** or **"for sale."** If a kind of *limu* is picked for both purposes, write **both**.

c. Look at the figures for estimated amounts of each *limu* picked for **personal use**. Make sure these are all expressed in terms of **pounds per year**. Convert them if necessary, taking into account the amount picked per week (or month) and whether the *limu* is available year round. Then compute:

- the **total** number of **pounds per year** picked for personal use **for each kind** of *limu*. (Enter this in the third column across from the name of the kind of *limu*.)

- the **total** number of **pounds per year** of *limu* **of all kinds** picked for personal use. (Enter this at the bottom of the third column under "total.")

d. Look at the figures for estimated amounts of each *limu* picked **for sale**. Make sure these are all expressed in terms of **pounds per year**. Convert them if necessary, taking into account the amount sold per week (or month) and whether the *limu* is picked year round. Then compute:

- the **total** number of **pounds per year** picked for sale **for each kind** of *limu*. (Enter this in the fourth column across from the name of the kind of *limu*.)

- the **total** number of **pounds per year** of *limu* **of all kinds** picked for sale. (Enter this at the bottom of the fourth column under "total.")

e. Compute the **average price per pound** that the pickers who were interviewed receive for each kind of *limu*. Enter this in the last column across from the name of the *limu*.

f. Note at the bottom of the sheet the picker's opinions about any increase or decrease in *limu* harvest over the past few years, and any explanations they offered.

*If the name the picker used is different from those used in class, use either the scientific name, or agree on one Hawaiian name within your group. Note the name the picker used in the space at the bottom of the worksheet.

Research Topic Worksheet
Picking *Limu*

a. Kinds of *Limu* *	b. Personal Use/For Sale	Pounds per Year c. personal use	d. for sale	e. Price per Pound
		Total	Total	

f. Pickers' opinions about decrease or increase in *limu* harvest:

* Other names used by *limu* pickers:

Summary Discussion Questions

1. In the stores we studied, how many pounds a year do we estimate are sold of each kind of Hawai'i-grown *limu* and imported seaweed? Put these in order, from most to least sold. Which kind sells the most? Which the least?

2. Using the information we found about price per pound, put the kinds of Hawai'i-grown *limu* and imported seaweeds in order, from most to least expensive.

3. According to Heather Fortner's research, which kinds of Hawai'i-grown *limu* were most and least expensive in 1979? Compare these with the kinds we found to be the most and least expensive today.

4. Compare Fortner's price information with ours. Compute the **percentage** of increase or decrease in price for each kind of *limu*. For which kind of *limu* has the price increased the greatest percentage? the least?

5. Has the way each Hawai'i-grown *limu* is packaged or prepared for sale changed since Fortner did her research? If so, for which kinds? Why do you think these might have changed?

6. Compare the price per pound the *limu* pickers receive for each kind of *limu*, and the **average** price charged by the markets for each kind. Compute the **percentage** of mark-up by the markets.

7. Using the **estimated annual amount** of each kind of *limu* collected by *limu* pickers for their own use or family and friends, and the **average price** for those kinds of *limu* in the market, compute the **dollar value** for each kind of *limu* they pick each year.

8. Which explanation do you prefer for the decrease in the *limu* harvest in recent years? What evidence supports this explanation? How could we find out more about the causes for the decline in the availability of *limu* ?

G. *Limu* Conservation

Subject Areas: Social Studies
Environmental Studies
Values Education

Key Concepts:

One solution to the problem of declining supplies of *limu* is to educate people about the proper way to harvest.

Conservation regulations are only effective if people recognize the need for them, and support their enforcement.

Activity Objectives:

Students will reflect on the need for conservation of *limu*, the need for a *limu* conservation regulation, and the problems in enforcement of such regulations.

Students will propose plans for increasing the effectiveness of *limu* conservation efforts.

Skills Emphasis: critical thinking
problem solving

Materials:

two large sheets of paper and marking pens for each small group of students

Copies for each student:

Markrich, Mike. 1985. "Seaweed Harvesters Leaving Once-Fertile Areas Almost Barren." Honolulu Star Bulletin-Advertiser, October 6.

"Limit on Limu Picking Unopposed." Honolulu Star-Bulletin, June 11, 1986.

If students have participated in Activity F, it would be useful for them to have copies of the chart, **Quantities of *Limu* Harvested and Sold, 1977-1984**, page F7.

Management Suggestions:

This activity would be good to introduce after students have discovered the importance of *limu* in Hawai'i today, and have some idea of the problem of declining supplies, especially of *Gracilaria (ogo)*.

Time Needed: One class period.

Background:*

The new *limu* conservation regulation was over a year in the making.

- In November 1985, in response to the problem of declining availability of *Gracilaria (Limu manauea or ogo)*, the **Division of Aquatic Resources of the Hawai'i State Department of Land and Natural Resources** proposed a *limu* conservation regulation, which is summarized in the attached article.

- The provisions of the proposal were **discussed informally during public meetings** held statewide, in November, 1985.

- Then the proposed rule was taken to **formal public hearings**, as required by law, beginning in June, 1986. People were invited to testify in person, or to mail in written testimony

- Based on public input, the DLNR decided to pursue having the regulation adopted. The regulation was sent for adoption to the **Board of Land and Natural Resources**, which is the policy-making head of the DLNR.

- Upon adoption, the Board then sent the regulation to the **Governor** for approval.

More than a year passed from the time the *limu* conservation regulation was first proposed, to its approval by the Governor. This lengthy procedure, involving ample opportunity for both informal and formal public input, is required by law. The purpose of the procedure is to ensure that the public know about and support the new regulation. A law needs the support of the people if it is to be effective. If people have had input into the formulation of a law, they are more likely to obey it themselves, and to support its enforcement. On Maui, for instance, the people decided they wanted to **prohibit**, rather than simply limit, commercial harvesting of *ogo*. This provision is included in the new law.

*This information was provided by Dave Eckert, Division of Aquatic Resources, DLNR.

Procedures:

1. Ask students to form small groups. Distribute paper, marking pens, and copies of Mike Markrich's article to the students. Ask them to read the article, then to discuss the following questions in their groups:

a. What evidence do you have concerning the decline in the availability of *limu*, especially *Limu manauea*, or *ogo (Gracilaria)* ? You may draw from your personal experience or from information from previous activities (such as Activity F).

   - Summarize in writing the evidence of your group for this decline.

b. What steps might be taken to conserve the remaining *ogo*, and other kinds of *limu*, and to ensure their availability in the future?

   - List your recommendations, and for each one, state who would be responsible for making it happen. (For instance, if they suggest that more *limu* should be grown through aquaculture, do they recommend private industry, government projects? If they suggest that people pick more carefully or only "what they need", who should educate people, say how much is enough, and enforce a rule like this--families, schools, government agents?)

2. Ask representatives to summarize the findings and recommendations of their groups.

3. Distribute copies of the article about the new *limu* conservation regulation. Review the provisions with the class, and explain the steps through which this regulation has gone to become law. (Note Maui's extra provision.)

4. Then ask students to discuss the following questions in their small groups, and prepare to present their ideas to the rest of the class:

a. How likely do you think it is that most people will comply with the new regulation? For what reasons would people tend to obey, or break this rule?

b. How easy or difficult do you think it will be to enforce this regulation?

c. If people are concerned about conserving Hawai'i's *limu* supply, what else can they do to promote conservation?

Resources:

For more background on issues of marine conservation, see the following readings from the appendix to A Compendium: Coastal Field Sites in the State of Hawai'i, State of Hawai'i Department of Education RS 85-8050, June 1985:

• CONSERVATION [guidelines for collecting, or not collecting, marine organisms], pages A27-A30.

• AN INTRODUCTION TO THE EFFECTS OF RECREATIONAL USE OF ROCKY INTERTIDAL ECOSYSTEMS [report on research conducted in California], pages A67-A76.

• EFFECTS OF VISITORS ON A MARINE ENVIRONMENT [report on the effectiveness of conservation education in reducing human-caused damage to marine intertidal reefs], pages A88-A90.

Extension:

Advanced Hawaiian language students might enjoy the reading, *"Limu Kohu"*, reprinted in Appendix 4 of this guide. Part of this reading deals with the proper way to pick *limu*.

Seaweed harvesters leaving once-fertile areas almost barren

10-6-85

from the sea

mike martrich

Isabella Abbott is a world recognized authority on the popular local seaweed known as ogo. But even she doesn't know where to find it on Oahu anymore.

Commercial harvesters have taken so much of this once-plentiful seaweed for use in poke (a raw fish and seaweed entree) that many of the places where she once went to look for this limu are now barren.

"It's the same old story," Abbott said. "You can follow the collectors from Haaauma Bay to Waianae over a period of months and you can tell where they have been every step of the way . . . There's bare rock where I knew there used to be plants. From Nanakuli to Waianae, it's clean as a whistle."

She said the problem is the way in which people are harvesting for what she estimates is a $300,000 a year ogo market. She said that rather than cutting off the top of the plant with a knife so that it grows back, many commercial gatherers pull out the entire plant by the roots. As a result, the plant is not able to grow again in the same place.

"It's like pruning a fruit tree," said Abbott, who has studied seaweed for more than 40 years. "If you trim the branches carefully, the tree will grow back even fuller than before. But if you cut it in half and pull up the roots, that's it."

Abbott said ogo only grows in certain areas along the shoreline where rocks sit upon a sandy bottom to a depth of approximately 4 feet.

She said that because the plant is so selective in its choice of habitat, it does not grow back again in the same place when pulled out.

In Chile, Abbott said, so much ogo has been pulled off the rocks in recent years to satisfy the seaweed export market that it has become an endangered species.

Although the problem has not yet reached that stage on Oahu, there is concern among people living on Kaneohe Bay that ogo-growing areas there are disappearing.

"I think maybe that the people [illegible] pick the ogo," said Ernie Choy, who works with his family at the Deli at the end of Heeia Kea pier on Kaneohe Bay.

Choy said that from his window he can look out over the bay and watch entire families move from ogo patch to ogo patch taking everything in their path.

Kaneohe fisherman Malcolm Varde said he thinks part of the problem is that the people picking the ogo are immigrants unfamiliar with the way things are done in Hawaii.

"The local people know [illegible] know. They have a set of rules that means that they pick some for themselves but leave [illegible] behind some for [illegible] else. These guys pick for subsistence purposes to sell . . . They come in 10 or six at a crack in inner-tubes and you know they're not picking 20 pounds for tonight's poke."

But University of Hawaii Sea Grant Extension agent Mark Suiso said it is wrong to blame immigrants for the problem. He said that gathering ogo to sell [illegible] many of them can feed their families, Suiso says, "local people are just as greedy as anybody else.

"The whole attitude is that if I don't take this limu, somebody else will, so I better get all . . . The problem is that the state says that everybody has open and equal access to everything in the ocean."

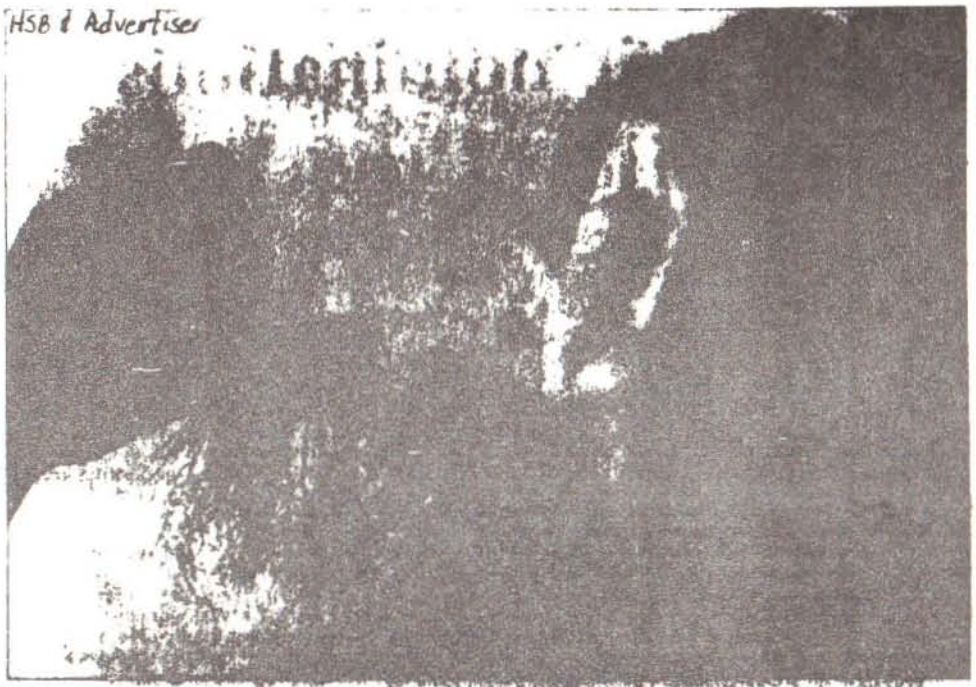
Director Henry Sakuda said his state Division of Aquatic Resources has received a number of calls about the ogo problem. He said a new regulation concerning the taking of ogo is being drafted and that public hearings are planned to discuss it. But he said the real need is to educate the public about the proper method of picking or cutting the plant.

Abbott said people need to learn to conserve ogo by picking or cutting the leaves but leaving the stem and root.

I asked her if she would take me to some of her favorite ogo picking areas.

"It would be a waste of your time and mine," she said sadly.

HSB & Advertiser



As she examines manuwai seaweed, Isabella Abbott says "You can follow the collectors from Hanauma Bay to Waianae over a period of months and you can tell where they have been every step of the way . . . There's bare rock where I knew there used to be plants. From Nanakuli to Waianae, it's clean as a whistle."

Advertiser photo by Carl Vitt

Limit on Limu Picking Unopposed

HSB 6-11-86

A proposed conservation law that would limit limu picking in Hawaiian waters went unopposed at a public hearing last night, one of a series of statewide sessions being held on the measure.

Limu is a seaweed which is used in many cultural dishes, such as Japanese miso soup, Filipino salads and the Hawaiian poke (pieces of raw fish with onions).

The proposed rule would prohibit taking of "ogo" and "limu manauea":

—With holdfasts or roots.

—With reproductive nodes, the small dark nodules or bumps on the stem and branches from which spores are produced.

—In quantities of more than one pound per person daily for home consumption, and 10 pounds per commercial licensee.

"What we're trying to do is equitably distribute the resource" because of the dwindling limu supply, said Henry Sakuda of the Aquatic Resources Division of the state Department of Land and Natural Resources.

No one showed up to testify at last night's hearing, held at the Kalanimoku state office building on Punchbowl Street.

Another Oahu public hearing is scheduled at 7 p.m. tomorrow at the Sunset Beach Elementary School cafetorium, 59-360 Kamehameha Highway.

Written testimony will be received until July 10 by the Division of Aquatic Resources, 1151 Punchbowl St., Room 330, Honolulu, 96813.

H. *Limu* for Lunch

Subject Areas: Social Studies
Language Arts
Home Economics

Key Concept:

Limu remains an important component of the diets of people of many cultural backgrounds in Hawai'i today.

Activity Objectives:

Students will be able to read and summarize background information about current uses of *limu* as food in Hawai'i and the mainland United States.

Students will be able to prepare one or more *limu* dishes.

Skills Emphasis:

reading comprehension
following directions

Materials and Equipment:

copies of the attached articles for each group of five students:

1. Abbott, Isabella A. 1978. "The Uses of Seaweed as Food in Hawai'i." Economic Botany 32 (4) 409-412.

2. Castenada, Laura. 1986. "Discovering the Joy of a Seaweed Sandwich." Honolulu Star Bulletin-Advertiser, August 3.

3. Connors, Michael. 1986. "The Northwest Meets Nori." Honolulu Star Bulletin, March 19.

4. Markrich, Mike. 1982. "Limu--Choice Depends upon Personal Preference, Heritage." Honolulu Star Bulletin-Advertiser, October 17.

5. "Limu Lesson." 1985. Honolulu Star Bulletin-Advertiser, November 17.

6. Yardley, Maili. 1979. "To Know and Eat Limu." Honolulu Advertiser, July 26.

copies of the ***Limu* for Lunch worksheet** and **instructions** for each student, plus one **extra worksheet** for each small group of five students

copies of the ***Limu* Recipes** for each student

food preparation equipment including: measuring cups and spoons, knives and cutting boards, mixing bowl (or cooking pot if needed); see recipes for amounts of specific ingredients.

Time Needed: two to three class periods

Background:

Seaweed is a part of the diet of many cultures around the world. In the United States, there is increasing interest in eating seaweeds. Especially in Hawai'i, people from many cultural backgrounds pick and/or buy seaweeds to prepare and serve as a part of their meals. For some people, seaweed is a traditional food, for others it is a new, and enjoyable discovery.

This activity involves students in reading and discussing articles about various seaweeds as food, and trying a sample of *limu* recipes from different traditions.

Management Suggestions:

1. In assigning students to read the articles which accompany this activity, ask them to work cooperatively in groups of five.

    a. Each student can read one of the newspaper articles and report the important points to the small group.

    b. All should read the journal article by Dr. Abbott for an overview of *limu* as food in Hawai'i.

2. Students can use the ***Limu* for Lunch worksheet** individually to record the information from their articles, then work together in the small groups to summarize the information from all the articles on a joint worksheet.

3. Students can work in pairs or small groups to prepare different *limu* recipes.

4. It may be possible to invite a student's relative to demonstrate cleaning and preparing *limu* in different ways.

Procedures:

1. Ask students:

    a. Do any of you or your families and friends eat *limu* grown in Hawai'i?

    b. Which kinds do you like best?

    c. Briefly, how are these *limu* are prepared and eaten?

    For instance:
    - just with salt
    - in a sauce such as *miso*
    - fresh in a salad
    - in seaweed soup
    - mixed with *poke* fish
    - in *kim chee*
    - cooked with meat in stew

    d. Do you also eat other kinds of seaweed which are imported to Hawai'i, such as *nori* in *makizushi* or *kombu* in soup?

2. Assign students to read the articles accompanying this unit. They should look for the following information, and can use the ***Limu* for Lunch worksheet** to record it for class discussion:

a. According to these articles, what kinds of seaweeds are preferred by people of Hawaiian, Japanese, Korean and Filipino ancestry?

b. What kinds of seaweeds, mentioned in the articles, are being eaten by people on the mainland?

c. What are some ways different kinds of seaweed are prepared for eating?

d. Which of these recipes have the students themselves tried?

e. Are there other kinds of *limu* students have eaten, prepared in one of these ways, or in another way?

f. **Special note:** the three newspaper articles about eating limu in Hawai'i all mention something about how to pick *limu*--what is it?

(Cut the "stem" [stipe], don't pull it out by the "roots" [holdfast].)

3. Ask representatives from each group to report their findings, noting especially which ways of eating *limu* are currently most popular among the students, including any not mentioned in the articles.

4. If there is a sanitary cooking area available, students can work in pairs or small groups to prepare different *limu* dishes. *Limu* should be washed thoroughly with tap water before being used in recipes. "Wilting" the *limu* is optional. See recipe sheet for "wilting" instructions.

Use the *limu* as directed in the recipes. In addition to those listed on the recipe sheet, there are four recipes (two for *kim chee*)in the newspaper articles included in this unit. For more recipes, see the Resources mentioned below.

5. Share the different *limu* dishes. Enjoy!

Resources:

Recommended: An especially good resource for *limu* recipes of all sorts is Heather Fortner's The Limu Eater (pp. 43-78). See also the recipes in Isabella Abbott's Limu: An Ethnobotanical Study of Some Hawaiian Seaweeds (pp. 6-7), and Magruder and Hunt's Seaweeds of Hawai'i (pp. 100-101). For simpler recipes, see also the Reef and Shore volume of the Sister Edna Demanche's Hawai'i Nature Study Program, p. 32.

Student Instructions
Limu for Lunch

1. Read the assigned articles. You can use the ***Limu* for Lunch** worksheet to organize and record the following information:

   a. The articles refer to the *limu* preferences of people of different cultural backgrounds, or of people who live in the mainland United States.

   Write the **cultural background or location** of the people in the first column on the worksheet, one per section going down the page.

   b. List in the second column the **kinds of *limu*** the different people are reported to prefer.

   c. In the third column, on the same line as the kind of *limu* in the second column,write a few words about **how each kind is prepared** for eating. If this preparation has a name (e.g. *makizushi* or *poke*) use that.

   d. Have you eaten any of these *limu*, served in these ways? For every kind and preparation **you have tried**, put a check near it in the fourth column.

   e. Are there **other kinds** of *limu* you have eaten, prepared in one of these ways, or another way? Make a note of this on the back of the paper.

2. Working in your small group, you can compare notes on all the articles and complete a worksheet for the whole group.

   a. Take turns sharing the information from the articles you each read, using the worksheets you completed individually. One student can be recorder, summarizing this information on the group's worksheet.

   b. Be sure to find out and record how many students in your group have tried each kind of *limu* , prepared in each different way. Also find out if there are other kinds of *limu* or other preparations that group members have tried.

3. One or more representatives of your small group can use the group's worksheet to report your findings to the class.

Limu for Lunch

a. Cultural Background or Location of People	b. Kinds of *Limu* Eaten	c. How Prepared	d. Number of Students Who Have Tried

In the three newspaper articles about *limu* in Hawai'i, what point is made about how to pick them?

Limu Recipes

Adapted from: Coral: A Hawaiian Resource. An Instructional Guidebook for Teachers by Ann Fielding and Barbara Moniz. State of Hawai'i Department of Education RS 81-0652. March 1981

Limu should be washed thoroughly with tap water before using. "Wilting" is optional.

To "wilt" *limu:*

Place the clean *limu* in hot (but not boiling) water, to cover. Let it sit in the hot water for a short time, from a few seconds up to a minute. Then pour off the hot water and rinse the *limu* immediately in cold water, to stop the "wilting" process. If it "wilts" too long, the *limu* will become like a soft gel.

1. **Kim Chee Ogo (Korean Style)**

1 lb. ogo (*Limu Manauea, Gracilaria* species)
1/2 cup shoyu
1/4 cup vinegar
1 Tbsp. mirin
Ginger, grated (to taste)
Chili pepper, grated (add to taste)
Garlic, choped fine (add to taste)

After cleaning the *limu*, and wilting it if desired, mix the seasonings and add to the *limu*. This kim chee may be bottled and kept in the refrigerator.

2. **Kailua Ogo**

1/2 cup red wine-vinegar
I lb. ogo
I tsp. sugar
1 tsp. chives (diced green onions)
1/4 diced tomato
Hot sauce to taste

After cleaning the *limu*, and wilting it if desired, mix the seasonings and to the *limu*. This may also be bottled and kept in the refrigerator.

3. **Pickled *Codium***

1/2 lb. *Codium* (*Limu wāwae'iole* or *'a'ala'ula*)
1/2 cup wine-vinegar
1/2 tsp. sugar
1/4 diced tomato

Clean the *codium* using only cold water. Mix ingredients to make sauce. *Codium* toughens rapidly in the sauce. Another way to serve this is to use the sauce as a "dip."

4. **Limu Tsukudani** (serve with hot rice)

I lb. ogo
1-1/4 cup brown sugar
1/2 cup mirin
1-1/4 cup shoyu
1/4 tsp. monosodium glutamate (MSG) (optional)

Clean *limu*. Mix sugar, mirin and shoyu together in a heavy saucepan. Bring to a full boil. Add *limu* and stir frequently to prevent burning. Cover and cook to a "mush" (about 45 minutes). Goma (sesame seeds) and chili pepper may be added to taste.

THE USES OF SEAWEED AS FOOD IN HAWAII

ISABELLA A. ABBOTT[1]

Rapid and frequent air service to Hawaii has brought about a stronger westernization in food choices and food habits than was possible 30 or 40 years ago. The transport of more fresh foods from the Orient is also possible. Western fast-food establishments such as McDonald's and Kentucky Fried Chicken are patronized as heavily as similar places in California. They have nearly entirely replaced "*saimin* stands" of pre-World War II where a bowl of noodles and a bamboo stick of barbecued meat could be had quickly. Chinese restaurants are the favorite choice of students in ethnobotany at the University of Hawaii (polls taken in 1976, 1977), but there is no question that a hamburger or hot dog is everyone's favorite food, regardless of ethnic background.

Against this change in food availability and food habits, continued use of seaweeds in the diet is surprising. Those of Hawaiian, Japanese and Filipino ancestry, the principal ethnic groups historically having seaweeds in their diets, purchase enough seaweeds to keep several suppliers in business (personal observation). As used by these groups of people, seaweed food preparations appear to be unsuitable as additions to standard western meals. Their flavor is inherently "strong," i.e., very definite, unlike for example the relatively pallid string bean; they may look like tangled strings; their color (black, brown, purple, dark red) unlike most western foods. Where in a western menu would you place a dish containing seaweed dressed in soy sauce and sugar (all three items with a distinctive flavor); where cold rolls of rice wrapped in purple seaweed, and where chopped, salted fresh seaweed, intended to flavor something bland, but not used as a gravy or sauce? I suggest that two to three meals a week are probably traditional Hawaiian, Japanese or Filipino in the examples chosen above, the remainder being western, i.e., "meat and potatoes."

Hawaiian preparation of seaweed or *limu* (edible seaweed) consists of chopping or mashing the fresh raw weed, adding salt and perhaps fresh chili pepper, and eating it as a relish in a fish and *poi* (or more recently, rice) meal. *Poi* is derived from *taro, Colocasia esculenta* (L.) Schott, and is steamed then pounded with water into a sticky paste with a consistency like that of chocolate pudding. It is served cold and has a faintly acid flavor. The piquancy of a variety of seaweeds added to bland *poi* or rice has been one of the historical and current reasons for retaining seaweeds in the food choices of Hawaiians, used here to include only native Polynesian descendants.

From a list compiled by Reed (1907) of 70 "economic" seaweeds used by Hawaiians for food, Abbott and Williamson (1974) were able to identify 29 species by both Hawaiian common name and Latin binomial. The discrepancy reflects in part, multiplicity of Hawaiian names for the same species, or a lack of knowledge of the meaning of Hawaiian common names, resulting in inapplicable or inappropriate names for certain species.

It is at the native Hawaiian feast, a *luau*, that celebrates the first birthday of a child, or the 75th birthday of a parent or grandparent, or the 50th wedding anniversary that a variety of seaweeds is found on the festive board. At these times, those who know where certain species grow are charged with collection and preparation as their contribution to the feast. At least four species of algae commonly appear: *limu kohu* (*Asparagopsis taxiformis*, a red alga), *limu eleele*

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(*Enteromorpha prolifera* or other species of *Enteromorpha*, green algae), *limu manauea* (*Gracilaria coronopifolia*, a red alga) and *limu maneoneo* (*Laurencia nidifica*, a red alga). These are served on a piece of *ti* (*Cordyline terminalis*) leaf, and added to fish, chicken or pork as desired. Should raw fish be served, chopped *limu kohu* will be mixed with it (a mixture called *palu* or *po-ke*). It is said that those who are wealthy serve *limu kohu* with raw fish; those not so wealthy use chopped *limu manauea* (*Gracilaria* spp.). Should raw liver be served, *limu pakeleawaa* or *limu huluhuluwaena*—two native names for *Grateloupia filicina*, a red alga—is mixed with it. So specific and traditional is this combination that the seaweed is often called *ake limu* (liver seaweed).

There is very little transfer of Hawaiian preparations of seaweed to the food habits of other racial groups except for "*aku po-ke*," the preparation of raw fish (tuna as first choice, but other fish as well), cut into chunks and mixed with seaweeds. The success of many a cocktail party has depended on the availability and the freshness of this dish.

These species of seaweed, as well as other favorites, are available for sale in local fish markets. Cleaned, washed, pounded or chopped, they sell for $1.25 to $1.75 per 4 oz, making them at $5 to $7 per lb some of the most expensive "vegetables" in the world.

On the other hand, two species of a red alga, *Gracilaria* (*manauea* in Hawaiian; *ogo* in Japanese) are offered for sale in plastic sacks not only in the fish markets but in supermarkets as well at $1.25 to 1.39 per lb. They are not prepared for Hawaiian tables but intended for Japanese or Korean kitchens. Here, the seaweed is washed, drained, and hot water is poured over it to blanch it. A *miso* (fermented soy bean) sauce, a vinegar, or sugar-soy sauce is used to flavor the seaweed before serving. This has a strong seafood-like flavor, unlike most vegetables prepared for western tables. In 1976, there were approximately 80,000 lb sold (State of Hawaii, Agricultural Commodities) in Hawaii's markets of these two species alone. I estimate this to be about three times the quantity of all other Hawaiian species offered for sale.

I estimate that an equal quantity, or about 80,000 lbs of seaweed is gathered by various families for their own use each year. Whole families from grandparents to their small grandchildren are often seen at favored "*limu* places," gathering a variety of edible seaweeds, exchanging greetings and recipes with others, and enjoying a day in the sunshine. For these families, diving for the seaweeds is not as much enjoyed as combing through drifts of algae. Diving for seaweeds is now the work of young men who collect in small groups. This is in contrast to the traditional (Abbott & Williamson, 1974) Hawaiian collections which was the work of women, forbidden before the introduction of Christianity (1820) from eating a large variety of foods including pork, coconuts, most bananas, a variety of fish and the sea turtle. Women turned to shellfish and seaweeds for food, and became experts, many (personal observations) being known beyond the boundaries of their living areas for the excellence of their seaweeds or their preparations. Many Hawaiian women 40 to 50 years ago supported their families by collecting and preparing seaweeds for market. Perhaps twice as much was sold in those days as is sold now, paralleling the decline in *poi* consumption, which, as with other things, costs four to five times more now than it did then.

In old Hawaii, one of the important food items used in exchange by coastal people with relatives in the uplands was *limu*, much appreciated for its piquancy (and furnishing a variety of vitamins and minerals scarce in upland foods). *Taro* and sweet potatoes were often offered by uplanders in exchange for sea foods (Handy & Handy, 1972). Today, prepared *limu* is a most acceptable gift to take when visiting, whether prepared in Hawaiian, Japanese, Korean or Filipino ways

One of the most frequently seen foods containing seaweeds in Hawaii is "*norimaki*" or "*maki-sushi*," made by Japanese for picnics and snacks, sold in Japanese stores, delicatessens, and restaurants. Flavored rice, rolled around shredded shrimp, fish, eel or egg and vegetables is wrapped in sheets of *Porphyra* (*nori* in Japanese) and served cold. *Sushi* is well liked by all racial groups. No estimates are available for the quantity of *Porphyra*, a red alga imported from Japan or Korea to Hawaii, but the amount must be large because of wide use not only in *sushi*, but also in rice balls, and it is the main constituent of Chinese seaweed soup.

Estimates for the quantity of imported *kombu* (*Laminaria* species, brown algae) are not known either. Inasmuch as the primary Japanese use is for making soup stock, its occurrence is not as conspicuous outside of a Japanese home as is *Porphyra*.

The use of *kanten* (agar, derived from certain red algae) by Japanese as a sweetened and colored dessert that resembles gelatin pudding is diminishing because of its cost, currently (January 1978) $1.35 for 0.5 oz, or $43.20 per lb, nearly matching the price of a specialty agar used in bacteriological media at $48.50 per lb (Noble Agar, sold by Difco, Co., price quoted in 1977–78 catalog). This puts agar for food in the same price range as some grades of truffles or caviar.

Of the four Japanese dishes—*ogo* with sauce, *sushi*, *kombu* and *kanten*—all but the last are used by other racial groups, such as the Chinese, in Hawaii.

Filipinos possibly use more seaweed per person than do Hawaiians. They are a group more commonly encountered at the seashore than Hawaiians, more curious about uses of seaweeds, more interested in a great variety. They also collect larger quantities than do others. Their chief use of seaweeds is in salads, mixed with tomatoes, spiced with fresh ginger, green onions and seasoned with soy sauce. Species of *Codium*, a green alga, are among their favorite seaweeds in Hawaii. *Codium*, well-liked also by Hawaiians, is not eaten by Japanese as widely in Hawaii as in Japan. Only one out of 20 Japanese queried knew its Japanese name (*miru*) and had eaten it. Filipino uses of the fresh algae in salads have not been transferred widely to other racial groups.

Koreans, forming a relatively small portion of Hawaii's population as compared with Japanese, Filipinos or Hawaiians, have contributed a pickled seaweed relish that has been modified from one traditionally prepared with cabbage. Reactions are strongly divided to "*Ogo Kim Chee*" (made with *Gracilaria* spp.—*ogo* in Japanese—or *Halymenia* spp.), not to the seaweed (Abbott & Williamson, 1974) which constitutes the bulk of the relish but to the abundant seasonings of fresh garlic, fresh chili pepper and fresh onions. The lively pickle is made from numerous recipe modifications and is either proudly or diffidently offered to guests. Eating it leaves a lasting odor. In Hawaii some years ago, a bumper sticker admonished: Ban *Kim Chee*! Nonetheless, of all the seaweed dishes prepared in Hawaii, probably more people with different cultural origins eat seaweed *kim chee*.

In summary, about 18 species of Hawaiian seaweeds (Abbott & Williamson, 1974) are offered for sale or are collected for food by Hawaiians, Japanese, Koreans, Filipinos and a scattering of other racial groups. It is suggested that although most people living in Hawaii have become strongly westernized in their food choices (as documented by the contents of their grocery baskets and their patronage of fast-food restaurants), a large number remains that appear to treasure traditional seaweed foods, and hence provides a small but steady market for the essential ingredients. The five to six dried seaweeds available from Japan also maintain a good market. It appears that instead of losing the traditional methods of preparing these foods that are odd to the eyes of westerners, westerners as

well as all racial groups in Hawaii have come to enjoy and appreciate the dishes containing seaweeds that are prepared by others.

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H Hh

Discovering the Joy of a Seaweed Sandwich

By Laura Castanedo

SAN FRANCISCO Alice Green stood calf deep in the frigid bay waters at low tide listening to the muffled roar of morning rush hour traffic over the Golden Gate Bridge and the gentle splash of waves on the rocks.

As a steady breeze swirled patches of fog over nearby Fort Point Green kneeled down carefully plucked her dinner from a sea of brown mush and dropped the exotic looking morsels into a yellow plastic bucket.

The nutritious items gathered during the early morning jaunt were sea vegetables or edible marine algae. Green, who has taught about the subject for years said the Northern California coast is the best source of these foods in the world.

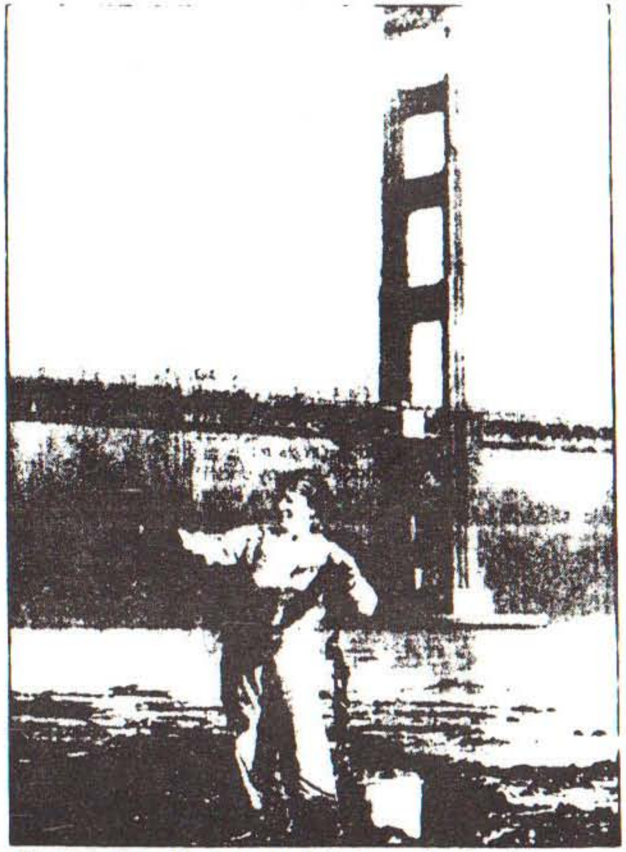
"The very richest places on the West Coast are Big Sur, Monterey and Point Lobos," she said. "Japan has more of an abundance than us and South Africa and New Zealand have variety. But we have both."

Over the past decade Green has taught more than 1,000 people the art of cooking and gathering sea vegetables through classes at City College, the University of California at Berkeley Extension and the [illegible] Field Seminar.

"When people are walking along the beach people see this slimy mass. The sea vegetables have started their natural [illegible] process. Sometimes the [illegible] of it and it looks unappetizing," she said.

[illegible] said eating sea vegetables is a natural and rational thing to do.

"[illegible] real exciting for me to go out and eat sea vegetables [illegible] connect with [illegible] directly," she [illegible] something [illegible] and these sea vegeta[illegible] [illegible] forms of [illegible] little [illegible]



Alice Green 'harvests' a large strand of alaria at the edge of San Francisco Bay. Green has been teaching people how to cook edible seaweed for the last 10 years

They're wild, uncultivated and biologically very simple forms. It takes me back to the very beginnings of life because they say that all life started in the ocean," Green said.

[illegible] wonderful source of food [illegible] people just don't know [illegible] she said, adding that [illegible] food can be used to feed the hungry all over the world.

Sea vegetables are most valued as a source of minerals, she said, adding that they are easily digested because of their gelatinous quality. They also provide protein [illegible] and vita[illegible] [illegible]

THE three groups of sea vegetables green, brown and red all look and taste different.

The plants can be cooked and dried, eaten raw, boiled, baked or deep fried. The textures range from chewy to crispy. Some taste like sweet grass while others are more akin to clams and oysters.

The most recognized types of sea vegetables are the greenish black nori which is dried and used to wrap sushi, and the greenish-brown bull whip kelp which has a large bulb on the end.

Others include the emerald green sea lettuce, the clear yellowish alaria, ogo which looks like stringy brown hair, and iridea which under water resembles a sheet of black rubber with brilliant hues of purple, greens and blues.

Green said people are interested in sea vegetables for several reasons.

Some people want to explore their own area where the wilderness meets the city," she said. "Others are interested in nature. Some want to do new and interesting things with food. Lots have heard of the nutritional value. And it's inexpensive and fun to gather."

Her enthusiasm and knowledge has impressed her former students. Laura Goldbaum of San Francisco who took the seminar about two years ago, said she found gathering in the early morning hours exhilarating and still goes out on her own.

"I was looking for a plant source of vitamin B-12. I was living with people who didn't eat any meat, dairy or eggs and I was afraid they were suffering from a vitamin deficiency," Goldbaum said explaining why she took the class.

"It just opens up a whole new world," she said. "When you walk on the beach you think of rotting seaweed. But once you learn about it, you see all these beautiful plants."

Green, 45, of San Francisco is a native of Portland, Ore. and a teacher by training. In 1965 she traveled to Japan and stayed for three years learning the different customs and teaching English for a living.

WHEN she settled in California, she decided to learn more about sea vegetables by taking a class in algology, now called phycology, which is the study of algae.

"I thought it was valuable for Americans to know what I had experienced in Japan, some of which was eating sea vegetables," Green said.

She also began researching how other nations use sea vegetables, plus their nutritional value, and she started creating her own recipes. Soon, her informal classes on the subject grew to their present popularity.

Green, who usually takes her students to Fort Point or to Point Reyes, said she'd like to try writing a children's book on sea vegetables because "it's never been done before. The market is good."

H19

The Northwest Meets Nori

By Michael Connors
Gannett News Service
H.SB 3-19-86

BELLINGHAM, Wash.—In the British Isles, it is hauled in from the sea and used fresh in salads or as a boiled green like spinach.

The Welsh call it *laver* and eat it with mutton.

And the Irish call it *sloke* and serve it with potatoes and butter.

The Japanese like it so much they cultivate it. A U.S. company has been running a test to do the same thing, calling it a "sea vegetable," not "seaweed."

The American Sea Vegetable Co. of Vashon Island, Wash., has been growing one specific kind, *nori*, in Puget Sound in cooperation with the Department of Natural Resources and a Japanese consultant.

Conclusion: Lummi Bay, on the Sound, is the best area for such crops, and, in fact, *nori* is a native of the Sound although never before grown commercially. Growing sea vegetables from test rafts there yielded almost 50 percent more product than similar operations in Japan's productive bays.

Now the problem is to introduce sea vegetables to more Americans.

Some health food enthusiasts already are familiar with the thin black-green sheets of dried *nori*, which are high in protein, niacin, iron and vitamins A, B and C.

Nori and other kelp also act preventatively, a McGill University (Montreal) study showed, to reduce by 50 to 80 percent the amount of radioactive strontium absorbed through the intestine.

Nori is used as wrappers for other food (Japanese *sushi*), as well as being cut up in rolls, sandwiches, dips, spreads and sauces, or toasted as chips, or used as a condiment.

To introduce *nori* to Bellingham-area residents, dishes using the slightly salty, mildly flavored leaves were served: *nori* tacos, a *tortilla* with a *sheet* of nori inside, then a filling of beans and spices; *nori* vegetable dip, a tasty blend of steamed *tofu* and *nori* condiment whipped in a blender, and *nori-maki-sushi*, a fishless, meatless mixture of spiced tofu, vegetables, rice and ginger rolled cigar fashion in a toasted leaf of *nori*. The cigar is then cut in thick slices and before eating, dipped in a sauce of *tamari* (strong, aged soy sauce) and ginger, or dipped into a plate of toasted sesame seeds for a slightly nut-like flavor.

Starchy riceballs, held together with two small squares of *nori*, were predictably bland but, tucked deep inside with the help of a chopstick, was an explosive little nugget of *umeboshi*, a highly fermented and very salty plum that, when it finally strikes its balance with the surrounding blandness, is very pleasing.

Potato soup, made like a chowder without the clams, was good and had garnishes of *nori* strips. *Nori* also was used, like paper, to fold and cut out intricate decorations to place on dishes of food.

NORI CHOWDER

"Sea Vegetable Gourmet Cookbook and Forager's Guide," by Eleanor and John Lewallen

2 quarts water
3 onions, diced
2 cups celery
3 medium-sized potatoes
½ ounce OR 1 cup roasted nori
Salt, pepper and herbs to taste

Saute onion, celery and *nori* in light oil or water for 5 minutes; cut potatoes while they are sauteeing.

Combine potatoes, herbs, spices, sauteed vegetables and 2 quarts water and cook 20 minutes. Puree two-thirds of the soup in a blender; mix in with rest for texture. Add further salt, pepper and herbs to taste.

TOFU-NORI DIP

Steam 1 pound *tofu;* break up and put in blender.

Add 3 to 4 tablespoons *nitsuke* (recipe follows).

Add some garlic powder to taste, 1 teaspoon *umeboshi* plum paste and herbs of choice. Blend. Garnish with scallions.

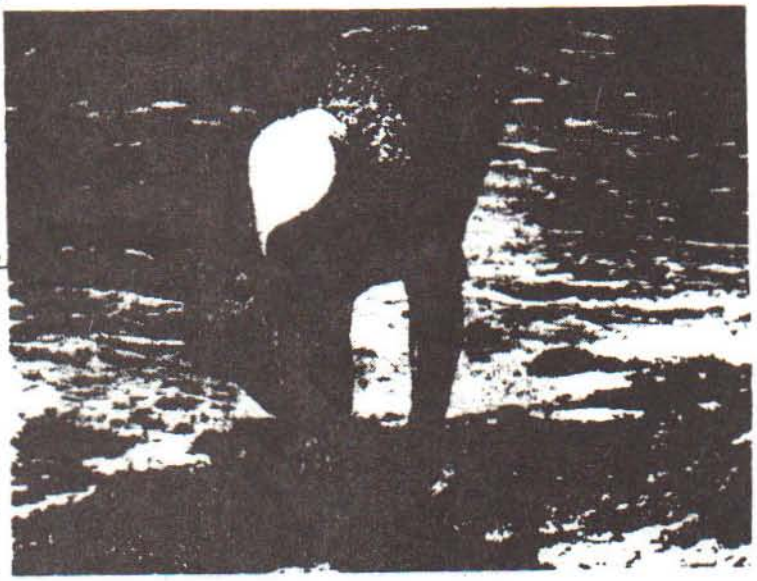
Nitsuke

10 pieces of nori, cut or torn in 1-inch squares
1 teaspoon salt
1½ cups water

Soak *nori* in salt and water for 15 minutes. Add ¼ cup soy sauce to mixture and cook 20 minutes after bringing to a boil.

H21

Limu—choice depends upon personal preference, heritage



from the sea

mike markrich

At the far edge of Ewa Beach where the chain-link fence divides the park from the military area, small groups of people work patiently sorting and resorting seaweed.

They are the limu gatherers (Limu is the Hawaiian word for seaweed.) Many have looked for limu since they were children and will spend hours choosing the three or four kinds they want from the approximately 100 species that wash ashore here.

The choice depends on both personal preference and cultural heritage.

An internationally known seaweed expert, Prof Isabella Abbott, explains: "You may like turnips. I may hate them. All of them are edible, but some you like better than others.

According to Abbott there are 18 species commonly used in Hawaii. The limu varies so much in taste and texture that it is collected by people with specific uses for it in mind.

"I know a lot of people who eat it Japanese style, pour hot water on it and mix it with miso. But when it comes to seaweed, I'm Hawaiian. I like it just plain with salt," Abbott said.

Filipinos tend to look for types of seaweed that are similar to those found in the Philippines. Types of limu that can be eaten fresh with salad and mixed in a fish sauce known as "bagoong" are the most popular. Rosa Sencia of Kalihi comes often to Ewa Beach with her granddaughter to look for limu. Says Sencia, "It's good, maybe tasting like in P.I., thin and long."

Abbott noted that limu is also an important ingredient in a Hawaiian fish sauce known as palu.

Because of the difference in tastes, the limu gatherers often do not compete for the same limu. Filipinos may prize a type of seaweed known to Hawaiians as huna in their fish sauce while Hawaiians would not collect it because they find it bitter.

Japanese people look for the popular ogo that is used for poki and many other dishes, while people of Hawaiian ancestry look for a wide variety of limu that can be used in different Hawaiian dishes.

Evelyn and Frank Giron of Honouliuli search for four kinds of limu at Ewa Beach. They look for waiwaiole (a green spongy limu known locally as "rats feet"), red lettuce, ogo and huluhuluwaena — a red limu they use for fish sauce.

Evelyn Giron says she collects limu for food and for health reasons. "This has iodine, it's good for you. Also it's important for roughage. She says she hopes her children will learn to collect limu so "they can know how to survive so in hard times they can go catch fish, get opihi and eat limu."

Ewa Beach is a popular place to gather limu because it has one of the largest varieties of seaweed of any easily accessible beach on Oahu.

The limu grows at a depth of six to 10 feet and the constantly rough waters at Ewa Beach are believed to pull the limu loose. This and the closeness of Pearl Harbor, which has brackish water seaweeds that drift over to Ewa Beach, account for the wide variety of seaweed that is found there.

The techniques of getting limu are as varied as the people who come for it. Some wade in the water to gather armfuls of the brown limu and then look through it carefully with sharp eyes and quick, skillful hands.

Others dive for it and pluck it out by its roots. Botanists discourage this method, because when it is pulled out it doesn't grow back. (The early Hawaiians are said to have always cut the limu with a knife, leaving enough so it would grow again.)

Those who have searched for limu for a long time just walk through the limu and feel for the ones they want with their feet.

There is a commercial market for limu and skilled gatherers such as a man who goes by the name Moresi Jr. He now lives in Kalihi but came there from Samoa and can gather with his family as much as 70 pounds in six hours.

Says Moresi Jr.: It's a kind of game. We gather them and we sell it for $1.50 per pound. The stores sell it for $2.50.

The most highly prized limu, limu kohu, is not commonly found at Ewa Beach. It [illegible] $[illegible] pound wet weight even though 90 percent of it is water.

Although there is some complaint that there are more people gathering limu and that there are more opala (slimy or junk limu) than ever before, the limu gatherers continue to come to Ewa Beach.

Abbott spends a large amount of time at Ewa Beach doing research. She has always found the people there happy and absorbed in their work of gathering limu. They don't find it tedious at all. They are interested in what they find. They are with their family and friends and it's a lovely day in the sun. Ewa Beach is one of the most [illegible] places on the Waianae coast.

Isabella Abbott's Ogo Kim Chee Recipe

2 pounds ogo chopped into 2- to 3-inch pieces
Handful of coarse Hawaiian salt
2 cloves of garlic (chopped) per quart of wilted seaweed
1 or 2 chopped round onions or 1/2 cup chopped green onions
chopped chili pepper to taste or 1/2 teaspoon cayenne pepper)
1/2 teaspoon paprika

Wash and clean the limu. Salt and wilt by letting stand over night. The next day, drain off any liquid, add garlic, onions and paprika. Pack tightly in jars, seal and let stand. It should be ready in two or three days.

Limu Lesson

11/13/05 SB/Ad

IF you're familiar with the beaches of California, you know upon occasion a foam like the head on some beer forms along the shore.

There's a reason shoreline foam is like beer foam. It's caused by the same thing, says Margo Stahl.

"It's the kelp in the nearby vicinity that gives foam to sea water and the same thing is used in beer," says the Windward Community College science instructor.

Beer is one of a myriad of products you eat and use that contain *phycocolloids*—seaweed, or *limu*, extracts. The extracts are "in everything from ice cream to chocolate milk to whipped cream. They use it in shampoo, toothpaste and cosmetics...In fact, it was in my avoset this morning," says Stahl.

"Most seaweeds are jelling or suspending agents and they are used because they give foods the consistency and thickness we find so desirable. And they are a very safe additive."

Seaweed as an additive is but a small part of the lecture Stahl will give Thursday on finding and preparing varieties of edible *limu*. The lecture, at 7 p.m. at He'eia State Park (formerly Ulu Mau Village), is part of a series sponsored by Friends of He'eia State Park and Windward Community College.

"First, I want to introduce people to the difference between *limu* and algae," Stahl says. "When people hear the term algae, many of them cringe because it connotes slimy things. Algae are really the ancestors of land plants.

"*Limu* are the larger marine algae—*limu* being the Hawaiian term for large marine seaweeds.

"There are three types broken down by pigments—brown, red and green. The most economically important are the browns and reds. Many people don't appreciate they use products made with these every day."

"People ask me 'Are all seaweeds edible?'" Stahl says. "And I always say 'Yes, if you don't break your tooth on them.' The larger red seaweeds deposit calcium carbonate in their walls and become stony like. Some people confuse them with coral heads. In fact, those seaweeds actually are responsible (in combination with coral) for most of our reef systems in Hawaii."

When it comes to eating seaweed, she says, "what to one person is *opala* (garbage) to another is *ono* (good). *Limu* preferences tend to be ethnically distinct."

Limu kala or Sargassum

For her lecture, Stahl has selected recipes and food preparation hints people in general will enjoy. She'll refer the hardcore *limu* eaters to a recommended list of books.

Among Stahl's suggestions is using *limu* for *tempura*. "You can use a variety of different species—*limu manauea* the most commonly preferred *limu* which is called *ogo* by the Japanese, or *limu kala* (Sargassum weed), for example.

"I like to use seaweed as an additive in *gazpacho* or mix it in *guacamole*. And it gives Mom's chicken soup a whole new meaning. It acts as a thickener.

"Don't be afraid to buy dried seaweed. Wash it in fresh water, slice it and experiment with it. You'll find it improves flavor and adds a whole new dimension to a lot of foods."

If you want to gather your own *limu*, Stahl says you can be comforted by knowing "you can't make too many mistakes when it comes to seaweed. You can't poison yourself the way you can with wild mushrooms, for example."

It "pays to learn a little before you go seaweed picking, she says. Do some research before you go—she suggests reading Isabella Abbott's "*Limu*, an Ethnobotanical Study of Some Hawaiian Seaweeds, and "Seaweeds of Hawaii" by William Magruder and Jeffery Hunt. Also, on your first outing, go with more experienced people.

"It's particularly important to learn how to collect *limu* so that you don't pull up the root system of the plant when picking."

The ocean science lectures series ends Dec. 5 with a talk by James Szyper on how to raise fish in your backyard. Szyper is the coordinator of Windward Community College's backyard aquaculture program.

The Island Way

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To know and eat limu

Summer time is beach time, and when you know how it's done you can make pleasant use of your beach time to enrich your family's diet, at no cost to anyone.

A printed guide to the gathering and preparing of Hawaiian seaweed is Heather J. Fortner's book, "The Limu Eater," complete with recipes for salads, pupus, relishes, soups, main dishes and miscellany.

Limu is the Hawaiian word for all water plants, including freshwater plants, lichens, mosses, and seaweed.

In common usage, it refers to the edible or useful seaweeds — ones used as medicine, in ceremony or as food.

Some seaweeds are essentially spices used sparingly to flavor or accent dishes, while others are as different and versatile as land vegetables.

Fortner's book contains old photographs from the Bishop Museum files and detailed line drawings of different types of sea weed.

It has pictures of old tutus, dressed in muumuus and lauhala hats, wading out into the ocean. Others are in groups on the beach.

The captions are a bit of nostalgia. "Where are the old women who would sit on the beach, surrounded by small children and infants, endlessly picking over the limu, removing each grain of sand, each coarsened stem, each lichen discolored leaf, while the other children and papa swam in and out, bringing more and more of the littoral harvest to their commodious laps?"

What memories that dredges up!

In our limu-picking days, we spent hours diving down to attack the limu beds, or treading very carefully on the reef at low tide.

Some preferred to pick limu from the washed up masses, but being in the water was much more sporting!

Whatever way you go after limu, like with mushrooms, you should know what you're picking!

Even back in the ancient Hawaiian civilization, *limu kohu* was considered the ultimate in seaweeds. This small, red limu was sometimes forbidden to all but the alii and was even cultivated in ocean gardens.

Today it is still highly prized and expensive. So it is no wonder limu-pickers won't disclose their secret *limu kohu* beds.

If you've ever picked *limu kohu* you can visualize a forest of tiny, pink pine trees waving in the water. These stalks with tufts of fuzzy branches vary from 1 to 8 inches.

They grow best where there is a constant flow of water, especially along craggy reefs in the surfline.

It is tempting to pull a handful from the rocks between waves, but for the good of the plant it is best to cut the stems and leave the base or seed to grow new stems.

Fresh picked limu is a chore to clean, it's full of coral pieces and sand.

Gently, you pound and rub it until the branches are clean. This takes time and several rinses by the seashore.

An overnight soaking in fresh water will reduce the bitter iodine flavor, but is not necessary.

Roll the clean limu into tight balls and pack in airtight containers. It will keep in the refrig indefinitely.

Eaten right from the jar it is usually used as a peppery spice with meat or fish.

The long, green strands of *limu 'ele'ele* are found at the mouth of streams in fresh or brackish water or in springs near the water's edge.

However today it is like finding gold!

Limu wawaeiole or Rat's Feet is also known as *miru* to the Japanese and *pokpoklo* to the Filipinos.

This dark green limu is velvety soft to the touch and has a spongy, almost cottony texture.

This one is fun to gather and is relatively easy at low tide.

Just pull yourself along by the rocks and feel. It grows in the form of a creeping mat over coral rock and sand without definite holdfasts at a depth of 1 to 15 feet.

A layer of sand and silt often covers the plant, making it difficult to locate and dreadful to clean!

But by rubbing it together between your hands in salt water and picking it over, it's not too bad.

Maybe this is why most people gather the shore-drifted plants that have been washed clean by wave action.

When using this limu in a salad, the freshly collected limu should be rinsed in salt water, then mixed with the dressing immediately before serving, as it wilts very fast.

The fresh plant can only be refrigerated for a few days before it softens, wilts and gets rather gelatinous.

TERIYAKI STYLE LIMU WAIWAEIOLE: Wash and clean the limu in fresh water, drain and chop into 2 inch lengths. Mix with 3/4 cup prepared teriyaki sauce, 1¼ tablespoons sesame seeds and ¼ cup chopped green onions.

The most common and popular limu in the islands is *manauea* or *ogo*, enjoyed by all ethnic groups. It grows in coral rubble on reefs, usually in shallow water. Once you harvest a big bagful, the most tedious job is to remove the *'opala'*. Another reason why beach-washed limu looks good!

There are many ways to serve this, but the old-time Hawaiians chopped and salted the limu, mixed it with other limu, fish or meat, and used it to thicken chicken and pork stews.

Today *ogo* can be prepared in many ways, and because of its mild taste is recommended for any beginner limu-eater.

OGO GUACAMOLE: Cut 2 large avocados in half, remove seeds and scoop out pulp. Mash coarsely with fork, blending in juice of ½ lemon.

Add 1 medium tomato chopped, 1 small chopped Maui onion, and 1 cup chopped ogo. Season with salt, and hot pepper sauce and serve with corn chips.

TRADITIONAL OGO KIM CHEE: Clean and wilt 2 pounds ogo, drain and chop up.

Combine the following: 4 cups water, 2 teaspoons red pepper, minced, seeds removed, 2 teaspoons minced garlic cloves, ½ teaspoon paprika, ½ teaspoon ginger root minced.

Mix with the ogo, pack tightly in jars, seal and refrigerate. Allow flavor to develop for few days before eating.

APPENDICES

1. *Nā Māhele o Nā Limu:* **Parts of Seaweeds**

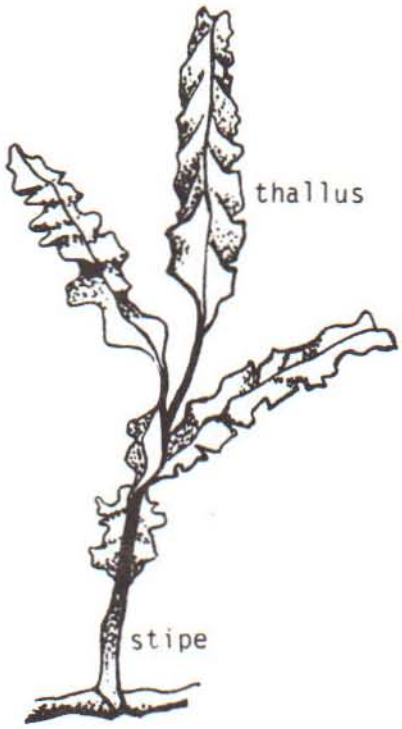
2. **Words and music:** ***"Ka Uluwehi o ke Kai"*** **(Plants of the Sea) by Edith Kanaka'ole**

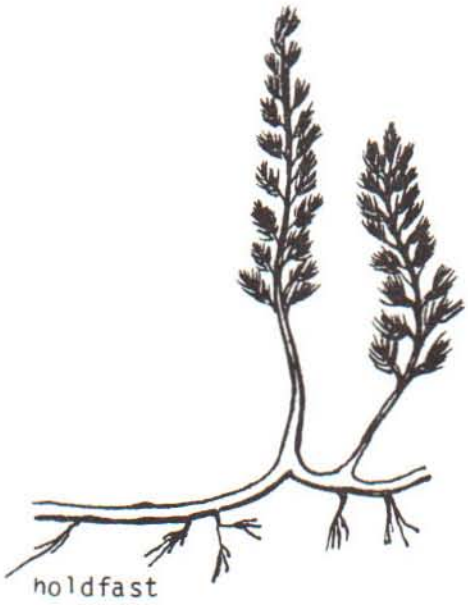
3. **Directions: Pressing and Mounting Seaweeds**

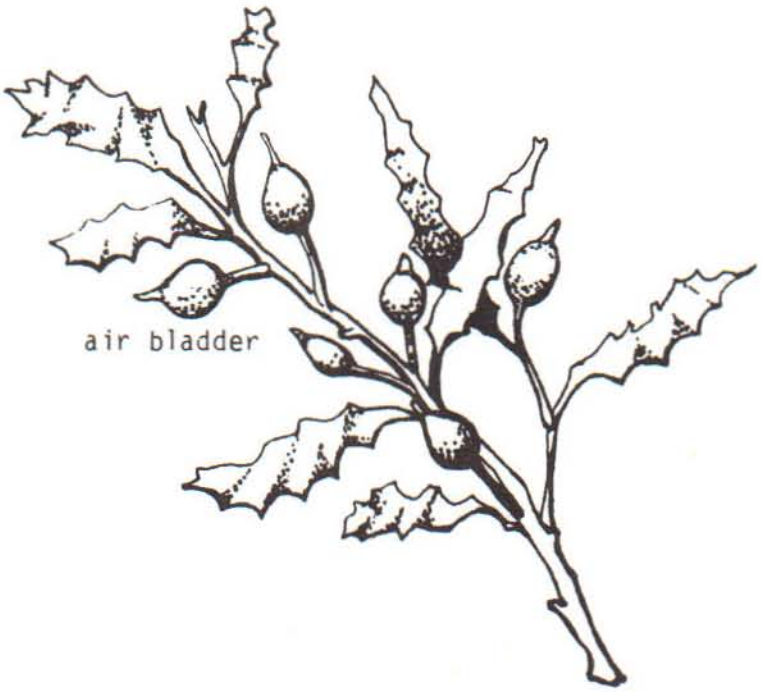
4. **Hawaiian reading:** ***"Limu Kohu"*** **from** ***Lau Kukui*** **Level II Hawaiian Reader**

5. **"*Limu:* Seaweeds or Seaplants" by *Hui 'Imi Na'auao o Hawai'i***

NĀ MĀHELE O NĀ LIMU: PARTS OF SEAWEEDS







Carolyn Kauanoelehua Chang

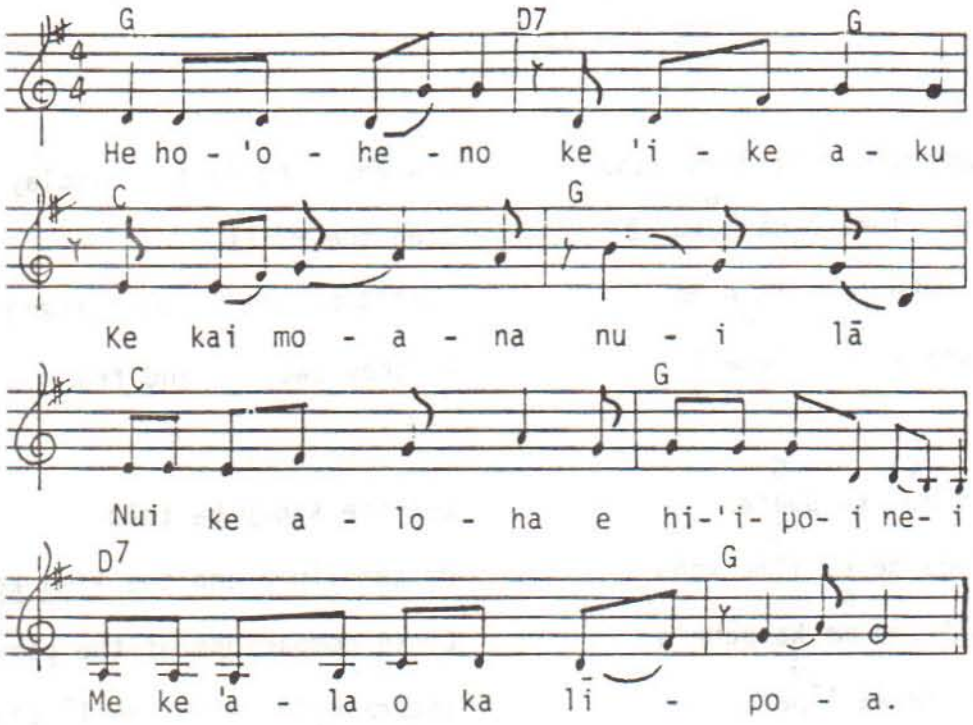
Reprinted from Na Mele Ho'ona'auao (Hawaiian Studies Music Resource Book)
State of Hawai'i: Department of Education, Office of Instructional Services,
General Education Branch. RS 85-7456 February 1985.

Ka Uluwehi o ke Kai
Edith Kanaka'ole

Carolyn Kauanoelehua Chang

KA ULUWEHI O KE KAI (Plants of the Sea)

Words, translation and music by Edith Kanaka'ole



KA ULUWEHI O KE KAI

PLANTS OF THE SEA

G D7 G
1. He ho'oheno ke 'ike aku — Such a delight it is to see
C G
Ke kai moana nui lā — The great big ocean
C G
Nui ke aloha e hi'ipoi nei — So familiar and very cherished
D7 G
Me ke 'ala o ka līpoa — With its fragrance of the līpoa

G D7 G
2. He līpoa i pae i ke one — It is līpoa which washed ashore
C G
Ke one hinuhinu lā — Onto the shiny white sand
C G
Wela i ka lā ke hehi a'e — Hot from the heating sun as you step on it
D7 G
Mai mana'o he pono kēia — Don't think that this is fun

```
    G              D7          G
3.  Ho'okohukohu e ka limu kohu
    C                        G
    Ke kau i luna o nā moku lā
    C          G
    'O ia moku 'ula la e ho
    D7                    G
    'Oni ana i 'ō i 'ane'i
```

How enticing is the display of limu kohu

Atop the rocks

(Enticing one to pick them)

As they sway to and fro

```
    G       C7       G
4.  Ha'ina mai ka puana
    C                    G
    Ka līpoa me ka limu kohu
    C           G
    Hoapili 'oe me ka pāhe'e
    D7                 G
    'Anoni me ka līpalu.
```

Let the story be told

Of the līpoa and the limu kohu

Close companions of the pāhe'e

Intermingled with the līpalu.

Ka holo: A7(2) D7(2) G(4)

Suitable for hula.

Recorded on: Hi'ipoi I Ka 'Āina Aloha, LP, Hula Records

PRESSING AND MOUNTING SEAWEEDS

Adapted from "Pressing Seaweeds" IN Coastal Awareness Program, 5th Grade Teachers' Guide, 1982 (draft), Leeward District Office, Hawai'i State Department of Education*

Materials Needed:

fresh seaweeds
large flat pan with about an inch of sea water in it
heavy, stiff white paper (e.g. botanical mounting paper, or unlined index cards)
several pieces of smooth, absorbent cloth (e.g. old muslin sheets, cut up)
lots of newspapers
weights (heavy books, bricks, etc.)
pencils
labels (see below)
razor blades or scissors
tweezers or toothpicks

Illustrated instructions appear on the following page.

Additional Suggestions and Tips:

1 Tap water may be used; however, the delicate red seaweeds will lose their water soluble pigments.

2. The natural adhesives in most seaweeds will cause them to stick to the paper as they dry. However, coarse, wiry, or stony seaweeds may not stick well to paper. These seaweeds can be pressed, then glued to the paper with Elmer's Glue or some other clear cement.

3. Many layers of mounted seaweeds may be pressed in one stack; however, the paper tends to crinkle if the stack gets too high. Boards may be added at the bottom and under the weights on top to keep pressure even.

4. Students can write the following information with pencils on one corner of each sheet of mounting paper. Later, this information can be typed or printed neatly on a label and placed over the pencil notations. Labels like the one illustrated below can be developed and duplicated for student use:

Scientific Name: _____
Hawaiian Name: _____
Date Found and Location: _____
Collection Notes: [about depth, substrate, brackish or fresh water, etc.] _____
Name of Collector: _____

***Additional Sources:**

Curriculum Research and Development Group. 1982. High School Marine Science Studies. Honolulu: CRDG University of Hawai'i. pp. 140-142.

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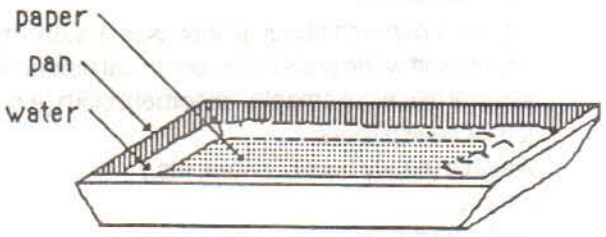
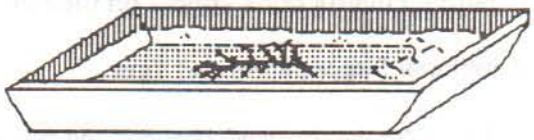
PRESSING AND MOUNTING SEAWEEDS

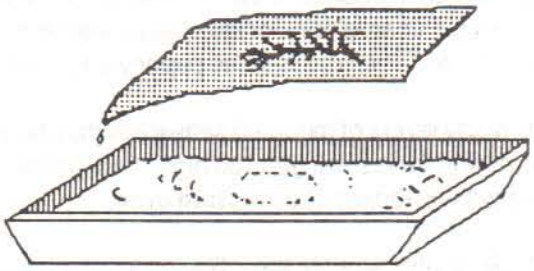
Step 1: Fill the pan with about one inch of sea water. Slide a sheet of paper in the pan.



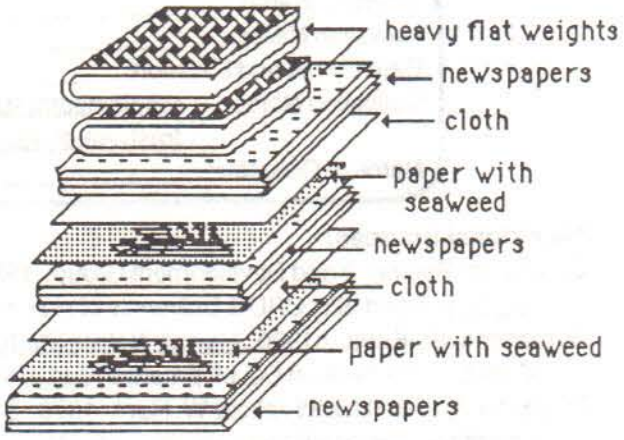
Step 2: Float a piece of seaweed in the water to position it on the paper. Arrange the seaweed "artistically" using a toothpick or tweezers. If necessary, thin out branches, using razor blade or scissors, to avoid too much overlapping.



Step 3: After you are satisfied with the arrangment, carefully lift out the paper and seaweed. Drain off the excess water. Then place a piece of cloth over the seaweed.



Step 4: Layer your materials as shown. Replace layers of newspapers as they become soaked. By changing newspapers, and with adequate ventilation, the mount can be completed within a 48-hour period.



Uses for Mounted Seaweeds:
Besides making a scientific collection of seaweeds, students may enjoy making stationery or note cards, bookmarks or framed pictures. See p. 31 of the Reef and Shore volume of Hawai'i Nature Study Program for procedures.

Reprinted from Lau Kukui, Level II Hawaiian Language Reader State of Hawai'i Department of Education, Office of Instructional Services, General Education Branch RS 81-2109 December 1981.

XIX. Limu Kohu

He aha ia mea 'o ka limu kohu? 'Ae. He mea 'ai ia mai ke kai ma. Ulu 'o ia i loko o ke kai ma luna o ka pohaku ma nā wahi papa[1] o ke kai. A ulu nō ho'i 'o ia ma nā wahi 'okaikai loa. He nui nō kona mau lalā e pili pū ana.[2] 'O ka lō'ihi o kēia mau lālā, he mau 'iniha wale nō, ma waena o 'elua a 'eono 'iniha. He 'ula kona kala.

Ke nānā 'oe i ia limu i loko o ke kai, 'ike 'oe i ka holuholu o kēia limu. Holuholu nō nā limu ma ke kūlana o ke kai,[3] i mua a i hope. 'Olu-'olu kou maka i kēia nānā 'ana.

Kūlou 'oe a ho'omaka i ka 'ohi. 'A'ole huki 'ino mai ka mole mai, no ka mea, inā ho'omau 'ia kēia hana e nā po'e 'ohi limu kohu, ma hope,[4] nele kākou i ka limu kohu. Pono nō e 'umiki i ka lālā. 'Ohi 'oe a pau kou makemake.

---

1 nā wahi papa o ke kai, reef areas of the sea

2 e pili pū ana, clinging together

3 ma ke kūlana o ke kai, according to the nature of the sea

4 ma hope, then, soon afterward

Limu Kohu

Iā 'oe e 'ohi nei[6] i ka limu, maka'ala 'oe i ke kai. He 'oia'i'o nō malo'o ke kai, akā, kekahi manawa pi'i mai ke kai a po'i ma luna ou a pulu 'oe. I kekahi manawa[7] lilo kāu 'eke limu i ke kai. Pono nō e 'ohi me ka maka'ala i ke kai.

'O ka ho'oma'ema'e 'ana i ka limu kohu, kaka 'oe i kēia mau limu i loko o ka pola wai kai, ka ipuhao, ke kini a 'o ka mea loa'a.[8] Wae 'oe i ka limu 'ē a'e me ka pōhaku li'ili'i a me ke one. Pono nō 'elua manawa e ho'oloili ai i ka wai kai. Inā 'a'ohe āu wai kai, ho'ohui 'oe i ka pa'akai me ka wai maoli. Mai ho'onui i ka pa'akai, ma hope[9] 'awa'awa loa ka wai.

Pau kēia hana, a laila,[10] 'oki'oki 'oe i ka limu kohu. Kāpī 'oe i kēia mau limu i 'oki'oki 'ia i ka pa'akai, 'a'ole i ka pa'akai Haole. Kekahi po'e, 'a'ole lākou makemake i ka 'oki'oki 'ana. No laila,[11] aia nō iā 'oe iho nō.[12]

Ka 'ai 'ana, hiki nō ke lomi 'ia me ka i'a maka, ka 'opihi, ke ake a pēlā wale aku. Kekahi nō,[13] hiki nō ke 'ai i ka limu kohu wale nō. Ka hana nui i koe,[14] 'ai 'oe me ka 'ono o ka pu'u.[15]

---

6 iā 'oe e 'ohi nei, as you are gathering

7 i kekahi manawa, sometimes

8 ka mea loa'a, whatever is available

9 ma hope, or else, lest

10 a laila, then, soon afterward

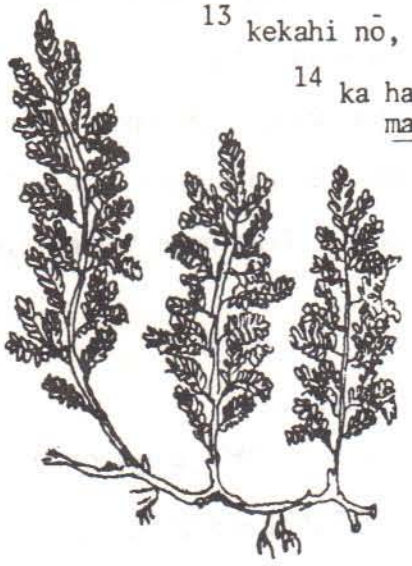
11 no laila, so, therefore

12 aia nō iā 'oe iho nō, it's up to you

13 kekahi nō, also

14 ka hana nui i koe, the major thing left to do

15 'ai 'oe me ka 'ono o ka pu'u, savor it, enjoy its deliciousness



Limu Kohu

Pilina'ōlelo:

We all know the kind of English taught in school is not the kind we usually speak outside of English or speech class. In fact, our language develops with us as we mature from babies to adults, so that by the time we are adults we no longer speak as we did when we were children.

We have what we call colloquial or conversational English (especially Hawai'i kind English) as used at home or with our friends, and we usually use standard English when we write a letter to the editor of a newspaper, for example, or when writing a paper for history class.

The few aspects of conversational Hawaiian appearing in the reading "Limu Kohu" are cited not because we are necessarily encouraging you to learn conversational Hawaiian. It is to make you aware that Hawaiian has both conversational and standard forms as do English and most other languages. You are to learn standard Hawaiian because there is a place for standard Hawaiian as there is for standard English. Conversational Hawaiian can be taught in a separate course to avoid confusion, because it's almost a whole new language in itself. In fact, the reading "Limu Kohu" is really not recorded strictly in colloquial fashion. It is a mixture of both standard and colloquial Hawaiian. But there is enough conversational Hawaiian to give you a taste of it.

Perhaps you have or will have the opportunity to engage in conversational Hawaiian with native speakers of Hawaiian; then you will have the ideal situation to pick up colloquial use of Hawaiian.

The following are some aspects of conversational Hawaiian as they are

used in the reading "Limu Kohu."

Ma hope replaces o, meaning "lest something happen."

Kahi replaces kekahi, meaning the indefinite article "a" or "some."

The topic marker 'o may be omitted before the definite article ka and the word kekahi, meaning "moreover" or "besides," when they occur at the beginning of a complete thought.

The preposition i, "in, at," may be omitted before the indefinite article kekahi when it occurs at the beginning of a complete thought. The omission of a, "when," may occur when the meaning "when" can be understood from the context, as in Pau kēia hana, meaning "When this is done."

The omission of the verb marker e (imperative) may occur at the beginning of a complete thought.

Ho'oma'ama'a I:

E kaha i laina ma lalo o ka hua'ōlelo 'ae a i 'ole o ka hua'ōlelo 'a'ole.

1.	Ulu ka limu kohu ma nā wahi 'ōkaikai loa.	'ae	'a'ole
2.	E huki 'ino i ka limu kohu mai ka mole mai.	'ae	'a'ole
3.	E maka'ala i ka 'ohi 'ana i ka limu kohu.	'ae	'a'ole
4.	E kaka i ka limu kohu i loko o ka wai wela.	'ae	'a'ole
5.	E kāpī i ka limu kohu i ka pa'akai Haole.	'ae	'a'ole
6.	Hiki ke 'ai i ka limu kohu me ke ake.	'ae	'a'ole

Ho'oma'ama'a II:

E kaha i laina a puni ka hua'ōlelo 'ē ma kēia mau māhele hua'ōlelo.

1.	'oki'oki	'umiki	kāpī
2.	'ike	'ai	nānā
3.	pa'akai	pola	ıpuhao
4.	wai	pōhaku	kai
5.	ho'oma'ema'e	kaka	pi'i
6.	'ono	'opihi	'awa'awa

Limu: Seaweeds or Seaplants
by Kilolani Mitchell

Traditionally, limu is the Hawaiian word used for the low orders of plants growing in and around fresh and salt water. Included here are mosses and lichens as well as algae. In usage the word limu now means edible seaweeds and a few that are useful for ceremonial or decorative purposes.

Seaweeds are part of the large, diverse group of plants called algae which are classified into four color groups. Although all algae contains some chlorophyll in order to carry on photosynthesis, this green color is masked in some species by pigments of blue, brown or red. Therefore, the classes are known as green, blue-green, brown and red algae. Within each group there is a wide color variation depending upon the amount of the pigments present, the season, where the plants are growing and the amount of exposure to light.

Poi and other vegetable foods, fish and flesh foods with the addition of limu furnished a nutritionally balanced diet for the Hawaiians of earlier times. Limu was usually eaten uncooked as a relish. The nutrients needed for growth and repair were furnished by the carbohydrates, fats and proteins in the animal and other vegetable foods.

Animal feeding experiments conducted by Professor Carey D. Miller at the University of Hawai'i Mānoa, give us data concerning the food values of limu. The commonly eaten limu 'ele'ele (green) and līpoa (brown) were used in these experiments.

The composition of the limu was 85 to 90 percent water, one and one-half to nearly three percent protein, one and one-half to two and one-half percent ash. There were traces of fat, calcium and phosphorus. Carbohydrate, if present was not in a form digested by humans.

Vitamin A. Limu 'ele'ele has less than half the Vitamin A of taro and līpoa had still less.

Vitamin B. Limu ele'ele had one-fourth and limu līpoa had one sixth as much Vitamin B as taro.

Vitamin C. was absent in these limu.

The roughage in limu helped prevent constipation. Iodine was present but secondary to that supplied by fish and by salt from sea water.

Hawaiian information estimated that adults would eat about two tablespoonfuls or more of limu each day.

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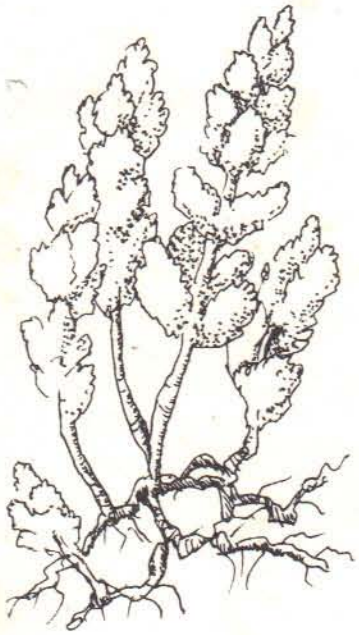

LIMU KOHU

This is a small red limu. In the water, it looks like a forest of tiny pink pine trees with tufts of fuzzy branches at the top.

Limu kohu grows well where there is a constant flow of water.

In ancient times, this limu was forbidden to all except the ali'i because it was desired for its peppery flavor and was considered the best of all seaweeds. It is usually used sparingly as a spice or a condiment. It is also combined with meat or fish in a stew.

Limu kohu appears to be found only in Hawai'i.

Hui 'Imi Na'auao o Hawai'i

LIMU 'ELE'ELE

Limu 'ele'ele means black seaweed and is descriptive of the dark color of the prepared seaweed. This limu is actually grass green in color. Long strands of limu 'ele'ele may be found growing at the mouth of many island streams. Its presence shows that fresh or brackish water is nearby.

The cleaned seaweed is rinsed and drained and salted. This prepared limu adds a nutty flavor to stews, saimin, and raw fish and its green color makes it a good garnish. It also can be eaten as a spice or dried in Japanese fashion to make a seasoning salt or thin sheets of sushi nori.

Hui 'Imi Na'auao o Hawai'i

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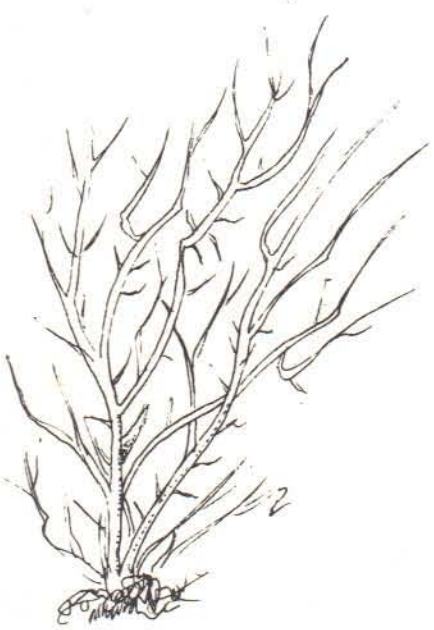

LIMU HULUHULUWAENA

In ancient Hawai'i, this limu was reserved for the ali'i. It was called the queen limu because of its dark hair-like branches. It was also considered the best edible limu.

This limu grows in different ways. Some have branches that are fine and hair-like, while others may be ½" wide. There are also flat, curled, and twisted varieties.

Traditionally, it is cleaned, rinsed in salt water, chopped and added to 'opihi, raw liver and other limu. It has a delicate but distinctive flavor when fresh and combines well with fish, poultry and dairy products.

Hui''Imi Na'auao o Hawai'i

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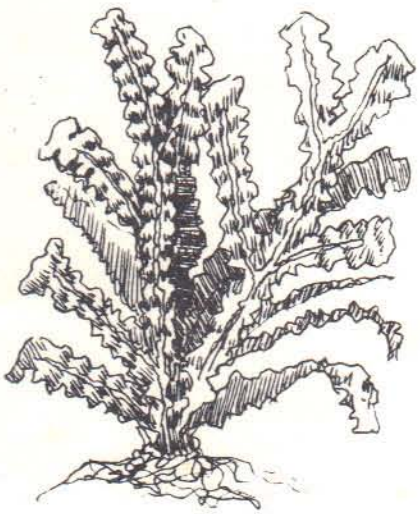

LIMU LĪPOA

Limu līpoa means gathered from the deep because this limu is a deep-water plant. It grows at three to fifteen foot depths, frequently in meadows, beyond the reef. It is not appreciated by the surfer and beachgoer because it clutters the water and the shore.

This limu has flat blades that are two to eight inches in length. It has a prominent dark brown midrib and is golden-colored with dark spots. It has a strong, perfume-like aroma and is highly favored for its unique spicy flavor.

Hui 'Imi Na'auao o Hawai'i

P

LIMU KALA

This limu is of ritual and medicinal importance to the Hawaiian people. The word kala means "to free, loosen" and "to forgive, pardon"; and thus it was used symbolically in many ceremonies.

This holly-like brown limu often has small inflated gas bladders which have flattened stalks. It grows in tide pools and reef flats and is commonly found on our beaches. Because of its leathery texture, it is not used much for food.

Hui 'Imi Na'auao o Hawai'i

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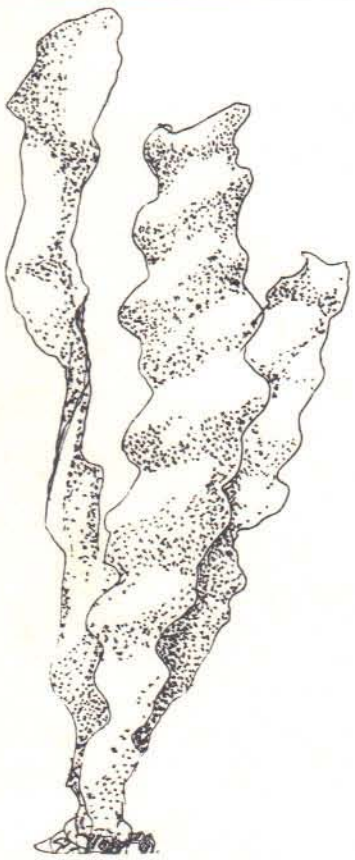

LIMU PĀLAHALAHA

This limu has long, flat, bright green blades. In the water, it resembles a leafy head of lettuce so it is often called sea lettuce. This limu is one of the most common limu in the islands and is found in abundance along the shore. This limu is edible but is rarely collected for eating. When it is prepared properly, it can be a delicacy.

A legend tells that an early ancestor of the shark was wrapped in the leaves of the limu palahalaha and then put into the sea. To this day this limu is thought to be sacred to the shark god and is kapu to people whose ʻaumakua is the shark.

Hui 'Imi Na'auao o Hawai'i

P

Limu - 10

OGŌ

This seaweed is not native to Hawai'i. It probably arrived here around the turn of the century by hitchhiking on the hull of a Japanese ship. The branches are cylindrical with pointed tips that are long and narrow. This is one of our larger red seaweeds.

The limu ogō grows in shallow reefs and is often washed up on the shore. The color varies from red, when it grows on the reef flats, to almost white when it grows in areas of bright sunlight.

This is the most popular limu for eating today. The mild flavor and crunchy texture is recommended for beginning limu eaters.

Hui 'Imi Na'auao o Hawai'i

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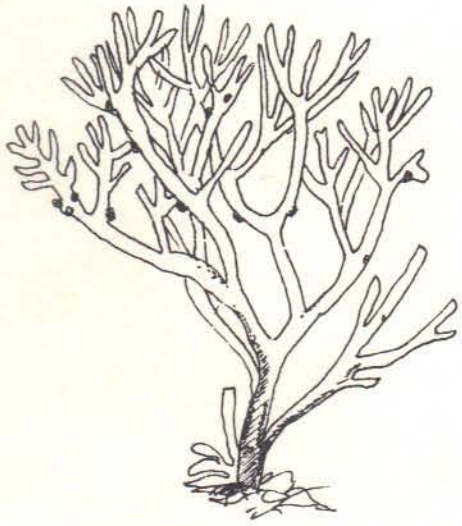
Limu - 6



LIMU MANAUEA

Limu manauea is a cousin to the limu ogō and is commonly referred to by that name. The limu manauea has a more reddish color and is shorter and more branched than the limu ogo.

This limu grows in shallow coral and sand reefs and is often washed up on the shore.

Like the Japanese ogō, the limu manauea has a mild flavor and crunchy texture. It is also one of the most popular limu for eating.

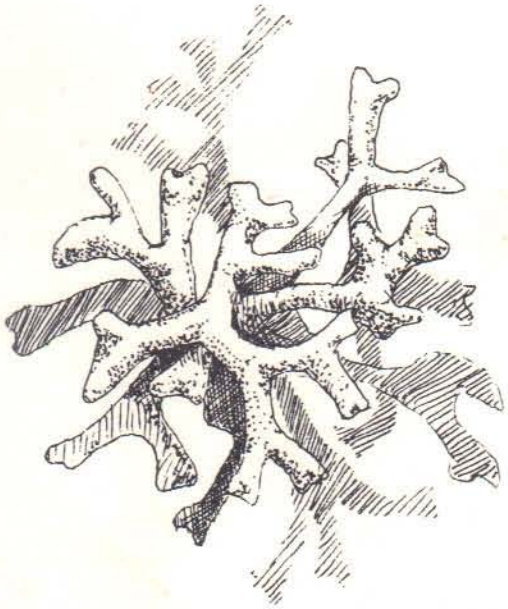
Hui 'Imi Na'auao o Hawai'i

LIMU MANE'ONE'O

This limu is peppery, almost hot to the taste, so it is sometimes called chili pepper or mustard limu. It combines well with raw fish and should only be eaten fresh.

Clumped at the base, this limu grows in bushes to a height of about eight inches. The tips of its branches have pits in them from which many colorless hair grow. This limu ranges in color from bright green to dark green and can be found growing in crevices and holes and along rocky coastlines.

Hui 'Imi Na'auao o Hawai'i



LIMU WĀWAE'IOLE

This spongy, green limu has stubby, flattened ends at its cylindrical branches that resemble a rat's foot, hence its name wāwaeiole which means rat's foot.

This limu grows in the form of a creeping mat over coral and sand. Frequently, when it is picked up, its bottom will be covered with pieces of shell, sand, or small rocks. It is found in abundance along the shore and is especially prized for eating by the Filipino people. It is called pokpoklo in Filipino and miru in Japanese.

Hui 'Imi Na'auao o Hawai'i