SEAWEEDS OF HAWAII

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By WILLIAM H. MAGRUDER
and JEFFREY W. HUNT

In Memoriam

To Dr. Gerald A. Prowse, a professor who expressed a genuine interest in his students and unselfishly shared his time and knowledge.

Acknowledgements

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SEAWEEDS OF HAWAII

A PHOTOGRAPHIC IDENTIFICATION GUIDE

By WILLIAM H. MAGRUDER

and JEFFREY W. HUNT

Cover: *Martensia fragilis* (top left), *Padina japonica* (top right), *Codium edule* (bottom left), *Predaea weldii* (bottom right)

Back Cover: *Asparagopsis taxiformis*

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TABLE OF CONTENTS

INTRODUCTION

Each year, thousands of island residents and tourists from all over the world visit the coastlines of the Hawaiian Islands. Some are only interested in lying in the sun, but many others show more ambition and curiosity, discovering that a great many strange and unusual organisms inhabit the marine environment. The interest shown by these people can quickly lead to frustration when attempting to learn even the names of these organisms, let alone anything else about them. This is especially true of the tropical seaweeds, where information for the interested layperson is virtually non-existent.

Scientific information concerning Hawaii's seaweed flora is widely scattered in various journals and publications that are written in a technical language that can only be understood by experts with years of training. An expert, even with this professional understanding of the technical language and a written description, still finds it difficult to identify a seaweed in his hands. Many times referral to a scientific drawing or even comparison to a herbarium specimen is needed. This small book of photographs is intended to allow the interested collector, student, SCUBA diver, visiting beachcomber, or scientist to easily identify the common Hawaiian seaweeds that are readily found when walking along the shoreline, snorkeling over reef flats, or SCUBA diving.

Depending upon the system of classification used, there are as many as fifteen groups or divisions of diverse photosynthetic organisms known collectively as the algae. Algae are found in almost every habitat in the world. They occur in snowfields, in hot springs, in the soil, on rocks and trees, inside other organisms, in streams and lakes, and of course in the ocean.

Within the divisions of algae are microscopic unicellular and colonial phytoplankton, and the larger, more commonly encountered macroscopic algae that are known as seaweeds if they occur in the ocean. In Hawaii, seaweeds are referred to as "limu."

The Hawaiian seaweeds presented in this book belong to the four divisions known as the Chlorophyta (green algae), Cyanophyta (blue-green algae), Phaeophyta (brown algae), and Rhodophyta (red algae). It is of interest to note that the names of these divisions were derived from the colors of the predominant photosynthetic pigments found in each division. This classification of the algae in accordance with their predominant pigments is the first example of the use of a biochemical characteristic for taxonomic

distinctions.

All the algae contain several different kinds of photosynthetic pigments in various combinations. One pigment they all have in common is the green pigment known as chlorophyll *a*. Most of them have an additional type of chlorophyll as well. For example, the green algae have a second chlorophyll, chlorophyll *b*, which along with chlorophyll *a* masks the small amounts of other pigments present, and consequently these seaweeds appear greenish in color. The other three divisions of algae described here contain large amounts of accessory pigments which usually mask the green color of the chlorophylls and produce the beautiful blue-green, brown, and red colorations characteristic of each division. The blue-green algae contain only chlorophyll *a*, but have in addition blue biliprotein pigments producing, in general, bluish-green colors. The brown algae possess a second chlorophyll, chlorophyll *c*, but both chlorophylls are hidden by the predominate xanthophyll pigments, producing brownish colors. Some of the red algae also have a second chlorophyll, chlorophyll *d*, but it is the abundant red biliprotein pigments that give them their reddish color. These various pigments are present in differing amounts and combinations in each species or even in individual seaweeds, thereby producing a limitless display of colors and hues.

There are other major differences between these algal divisions, such as the biochemistry of storage products and cell walls, the ultrastructure of their cells, the structure of reproductive bodies, and life histories, but these features are of little help if one is attempting to identify a seaweed in the ocean.

The form or morphology of each seaweed presented here is unique, but similarities exist among many of them. In general, seaweeds are attached to the bottom or other seaweeds by means of a holdfast (figures 1, 2, 3) or hairlike rhizoids (figure 4). In addition to a holdfast or rhizoids, most seaweeds usually exhibit an erect system and some may also have a prostrate system (figure 4). The erect system may take the form of a large expanded sheet or blade (figure 1), or a filament in a single row of cells (figure 2) or branched filaments, or it may be almost plantlike in appearance, with branches and leaflike structures (figure 3). Also, some green, brown, and red seaweeds become calcified through precipitation of calcium carbonate from seawater. The calcium carbonate precipitated by green and brown seaweeds and some red seaweeds is present in only small amounts and they therefore remain flexible. Some reds (the coralline seaweeds), however, incorporate large amounts into their cell walls becoming hard and stoney. Many of these coralline red seaweeds form prostrate crusts, but some are also jointed and erect (figure 5).

We hope you enjoy and appreciate the unusual beauty of form and color displayed by these often neglected organisms of the sea. If you are interested in more detailed information concerning the nature of these unique organisms, a list of scientific references for your use is provided at the end of this book.

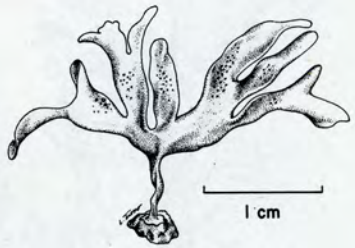


Figure 1. *Grateloupia hawaiiana.*

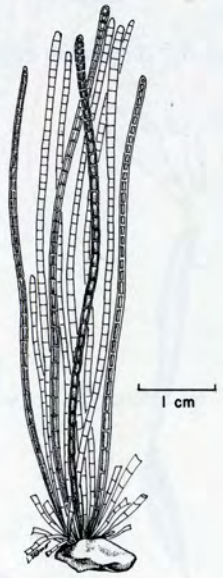


Figure 2. *Chaetomorpha antennina.*

Figure 3. *Sargassum echinocarpum.*

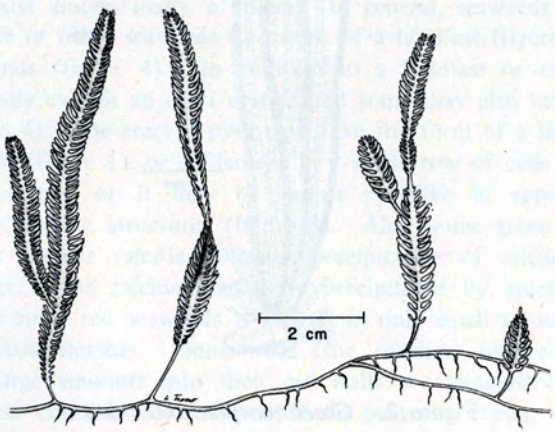


Figure 4. *Caulerpa taxifolia.*

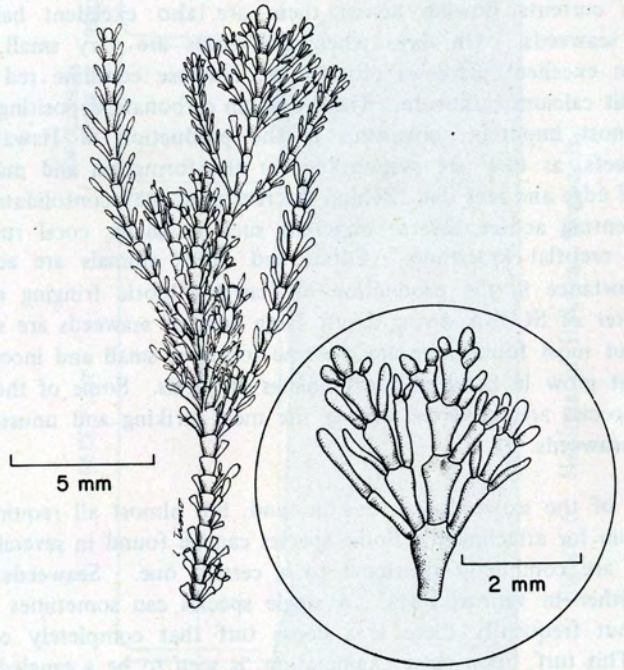


Figure 5. *Corallina* sp.

ECOLOGY OF HAWAIIAN SEAWEEDS

The Hawaiian Islands, with their varied coastlines, have a wide range of marine habitats in which seaweeds grow. In general, areas with a high degree of water movement, whether in the form of currents or waves, will support the most luxurious seaweed growth. Exposed rocky coastlines provide a range of excellent habitats for observing seaweeds, from calm protected tidepools to dangerous wave-swept cliffs, ledges, and channels. Reef flats that have currents flowing across them are also excellent habitats for observing seaweeds. On days when the waves are very small, the reef crest is an excellent place to observe the crustose coralline red seaweeds that deposit calcium carbonate. These calcium carbonate depositing seaweeds are the most important organisms in the production of Hawaii's biotic fringing reefs, as they are responsible for the formation and maintenance of the reef edge and reef flat. Behind the reef crest they consolidate, through their cementing action, diverse materials such as shells, coral rubble, and sand into reef-flat limestone. Corals and other animals are actually of lesser importance in the production of Hawaii's biotic fringing reefs. In deeper water of SCUBA diving depth, large beds of seaweeds are sometimes present, but most found here are crustose forms or small and inconspicuous species that grow in between the branches of corals. Some of these inconspicuous species are, however, among the most striking and unusual of the Hawaiian seaweeds.

A few of the seaweeds can live in sand, but almost all require a hard, solid bottom for attachment. Some species can be found in several habitats, but many are commonly restricted to a certain one. Seaweeds grow or occur together in various ways. A single species can sometimes dominate an area, but frequently there is a dense turf that completely covers the bottom. This turf, upon close examination, is seen to be a tangled complex of many species growing so closely intertwined that they are difficult or nearly impossible to separate. Even in habitats dominated by a single large species, there are many other small species that grow under or on the larger one.

In describing the occurrence of Hawaiian seaweeds we have used the terminology as presented in figure 6. Intertidal seaweeds are those that are exposed to the air by the change of tides. The intertidal area has variable environmental factors such as the topography of the shoreline, the type of rock, the size of the waves, and tidal fluctuations, that produce almost limitless different habitats for algae to colonize and thrive in. Related to these environmental factors are the forms of the seaweeds. For example, in the

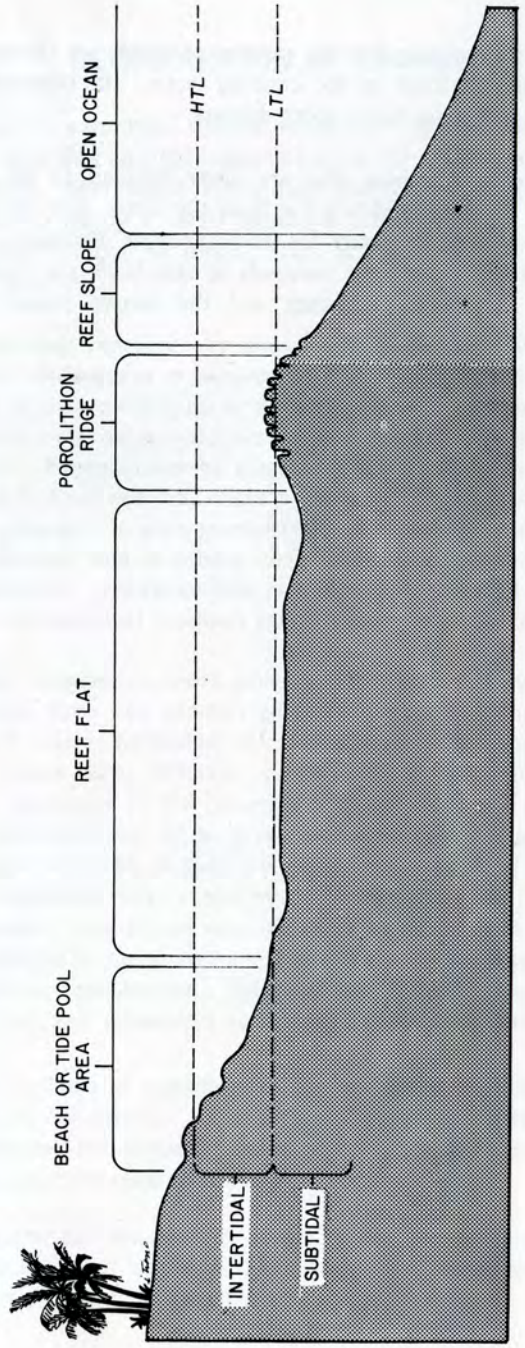


Figure 6. Habitats of Hawaiian Seaweeds.

face of the surf, seaweeds tend to be crustose or tough and flexible, enabling them to withstand the force of the crashing water. In tidepools or other quiet water areas they tend to be more delicate.

Subtidal seaweeds are those that are never exposed to the air by the change of tides. These seaweeds occur from the lowest low-tide line to the depth where the sunlight necessary for photosynthesis disappears, about 200 meters in Hawaii. The subtidal seaweeds in this book are found in such habitats as reef flats, bays, estuaries, and the deeper inshore waters of SCUBA diving depths.

REPRODUCTION OF SEAWEEDS

There is an extremely diverse variety of reproductive schemes found among the seaweeds and they have attracted the interest of many scientists. Much scientific information concerning seaweed reproduction is presently available but in hardly a single species is this knowledge so complete that new discoveries cannot be made. This is especially true for tropical and subtropical seaweeds.

Most seaweeds reproduce by microscopic single cells, either spores or gametes. Only when spores or gametes are produced in large areas on a seaweed can the site of their production be discerned without a microscope. Reproduction by spores is asexual reproduction, with each spore capable of growing into a new seaweed. Reproduction by gametes is sexual reproduction, with two gametes fusing to form one cell, called a zygote, which is then capable of growing into a new seaweed. In some species, male and female gametes are produced on the same seaweed, and in others, male and female gametes are produced on separate seaweeds. A seaweed that produces spores is called a *spore-producing phase* and a seaweed that produces gametes is called a *gamete-producing phase.*

For many seaweeds, a spore grows into a gamete-producing phase and the zygote formed from two gametes grows into a spore-producing phase. This is sometimes called *alternation of generations.* The spore and gamete-producing phases have different numbers of chromosomes and in many species the appearance of the phases may also be different, sometimes greatly so. The difference can be so great that they have mistakenly been given different names even though they are just different phases of the same seaweed. For some seaweeds only a gamete-producing phase or a spore-producing phase is present. In most red seaweeds there are two separate spore-producing phases in addition to the gamete-producing phase. Most seaweeds are also capable of vegetative reproduction. This involves the fragmentation of part of the parent seaweed and subsequent growth of the fragment into a new seaweed.

All the methods of reproduction and the different phases of a seaweed are termed its *life history.* Even among closely related seaweeds there can be very different life histories, and a single species may even have different life histories over its geographic range.

The simplest life histories are found in the blue-green seaweeds. Sexual reproduction does not occur in this group, but reproduction by spores and vegetative reproduction are common.

Both sexual and asexual reproduction are common in the green seaweeds. Similar-appearing spore and gamete-producing phases are present in the life histories of *Ulva fasciata* and *Ulva reticulata*. In *U. fasciata* the spores and gametes are produced in the cells near the edges of the blade; this area can sometimes be discerned by its light yellow color. In *U. reticulata* the spores and gametes are produced in cells in the middle of the blade. These cells then fall out, producing the holes (page 32) characteristic of this species. In the species of *Caulerpa* and *Codium*, only gamete-producing phases are present in their life histories.

Both sexual and asexual reproduction are also common in the brown seaweeds. The species of *Dictyota* and *Padina* have similar-appearing gamete and spore-producing phases in their life histories. *Turbinaria ornata* and the species of *Sargassum* have only gamete-producing phases. The gametes of *Turbinaria* and *Sargassum* are produced in visible structures called *receptacles*, which are present between the leaflike blades of most specimens. In *Rosenvingea intricata* and *Hydroclathrus clathratus*, only the spore-producing phase is present, and sexual reproduction appearently does not occur in these species.

Sexual and asexual reproduction are also common in the red seaweeds. This group has the most complicated life histories found among the seaweeds. The life histories of most species have a gamete-producing phase and two spore-producing phases, known as the *carpospore-producing* and *tetraspore-producing phases*. The gamete-producing and tetraspore-producing phases are free living but the carpospore-producing phase developes on the female gamete-producing phase. The swellings or bumps in the pictures of *Gracilaria coronopifolia* (page 72) and *Martensia fragilis* (page 84) are carpospore-producing phases that have grown on female gamete-producing phases. In a few cases, tetraspores can also be produced in visible distinctive areas such as in the swellings at the tips of the branches in the picture of *Gelidiopsis scoparia* (page 70). The gamete-producing and tetraspore-producing phases are similar in appearance in many species, such as the species of *Gracilaria*, *Pterocladia*, and *Hypnea*. However, in other species such as *Asparagopsis taxiformis* and *Ahnfeltia concinna*, the tetraspore-producing phases are very much smaller than the gamete-producing phases and have a very different appearance.

HOW TO USE THIS BOOK

The photographs in this book are grouped into the four divisions of Hawaiian seaweeds – the Chlorophyta, the Cyanophyta, the Phaeophyta, and the Rhodophyta – and arranged in alphabetical order within each division by genus and species. The scientific name is given for each species as well as the common Hawaiian name, when it is reliable and accurate. The scientific name of a seaweed, like all organisms, consists of two words comprising a binomial. The first word designates the genus and the second word the species.

Positive identification of seaweeds seen for the first time in the ocean usually requires the examination of microscopic features in a laboratory and a good knowledge of the terms used to describe them. Once proper identification has been made, it is usually possible to recognize the same species when it is encountered again. Each seaweed in this book was photographed in its natural habitat in the ocean. By familiarizing yourself with the photographs and comparing them to the seaweeds you find, you will be able to identify most of the large species found in Hawaii. Remember, though, that the seaweeds can be extremely variable in size, shape, and color, depending upon where and when they are growing. These photographs are of the commonly found forms, and the written descriptions give the normal size ranges, not extremes. For those not familar with the metric system a scale is provided on the inside back cover.

If you find a seaweed you are not familiar with, the color can often provide a quick guide to its classification and will allow you to place it in its correct division. After you know the division, look through the photographs in that division until you find the one that matches your seaweed. When observing a seaweed to determine its division by color, it is best to examine the lower inner portion, since bright sunlight can frequently change the color of the outer parts. This works with most species but unfortunately there are exceptions, especially among the tropical and subtropical seaweeds. The following color guidelines should be of some assistance.

The Chlorophyta (green seaweeds) are almost always grass green, but a few can be dark green or even whitish, and most turn yellow or white at the tips when exposed to bright sunlight that bleaches their chlorophyll. The marine Cyanophyta (blue-green seaweeds) are extremely variable in color, even within a single species. They can be blue-green, green, brown, red, black, gray, or yellow, but the three species in this book are fairly morphologically distinct. The Phaeophyta (brown seaweeds) are usually brown,

but several exhibit bluish or greenish iridescence and at least one is orange. If any part of a seaweed is red, it is almost always a member of the Rhodophyta (red seaweeds). A few red seaweeds exhibit bluish iridescence, and the tips of most will turn yellow or green in bright sunlight.

If you cannot readily tell by the color what division your specimen belongs in, a few simple biochemical tests may help. To distinguish some reddish-brown or brownish-red seaweeds apart, simply immerse them in hot water of 65°C for a few minutes. Most brown seaweeds will turn green in 120 seconds in water maintained at this temperature but most red seaweeds will not turn green in 240 seconds. The hot water dissociates the brown fucoxanthin pigments masking the chlorophylls, allowing the green color to be observed. The biliprotein pigments of most red algae do not dissociate in water of this temperature and the seaweed retains its reddish coloration. A few red seaweeds, however, do turn green with the application of 65°C water as you will notice if you blanch them with hot water as called for in certain recipes. Fortunately, these seaweeds are generally distinctly red in color (for example, species of *Gracilaria*) and are not easily mistaken as brown seaweeds.

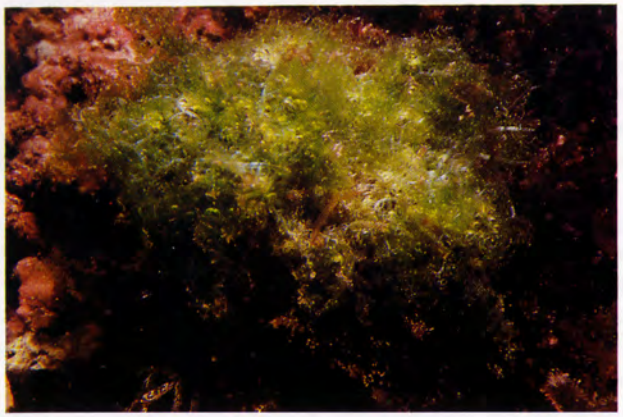
Delicate red and blue-green seaweeds immersed in freshwater will often give a pinkish to reddish tinge to the water. You may also notice that this often occurs if red or blue-green seaweeds are left in water in a plastic collecting bag. The water becomes colored by the extraction of the water soluble biliprotein pigments present in these red and blue-green seaweeds.

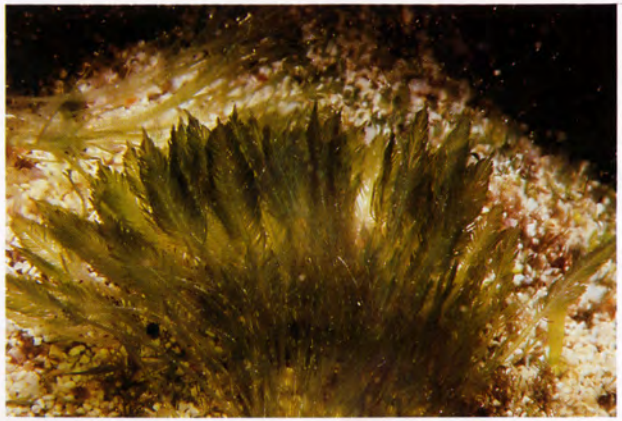
Similarly, when flooded with alcohol, some green and brown (and sometimes red) seaweeds will turn the alcohol greenish or yellowish. This occurs because alcohol (or other organic solvents) extract the fat-soluble chlorophylls and carotenoids present in green, brown and red seaweeds.

Finally, to determine if a seaweed is calcareous, a few drops of a dilute acid such as hydrochloric acid (HCL) will produce a rapid bubbling of CO_2 gas, indicating the presence of calcium carbonate.

While this book is intended basically for use in Hawaii, it will also be useful in other subtropical and tropical regions, since most of the genera and some of the species found here have a worldwide distribution in warmer oceans. Most of the same species also occur throughout the tropical Pacific Ocean. In fact, most of the species found in Hawaii are similar in appearance and closely related to species in the same genus found in temperate oceans as well.

You will doubtless find seaweeds that have not been included in the 118 species described in this book. Most of the smaller species have been omitted because they are difficult to identify without a microscope. The larger species that are rarely seen have also been omitted, although some of them may be abundant in certain places and in certain years. You may also find that you will be able to identify to the generic level some seaweeds not included in this book based upon similarities between your unknown seaweed and the photographs. There are also seaweeds in Hawaii that have not been described and given names. In fact, new additions to the seaweed flora of Hawaii are still being discovered. Who knows, you may even find one of these!





CHLOROPHYTA
(Green Seaweeds)

Boodlea composita

B. composita forms thick, rounded cushions 1 to 4 cm high and 2 to 8 cm broad that are made of a network of fine branching filaments. It has a delicate crispy texture, and the color is grass green, but may become yellowish green when exposed to bright sunlight. This seaweed is found in tidepools, on reef flats, and in lower intertidal habitats along rocky coastlines.

Bornetella sphaerica

B. sphaerica is easily recognized by its pealike shape and hexagonal surface pattern. Usually dark or grass green in color, it can become yellowish when exposed to bright sunlight. This seaweed reaches a diameter of 1 cm, and grows on rocky substrates in a variety of subtidal habitats, where it is often found under larger seaweeds.

Bryopsis sp.

The delicate soft featherlike appearance and dark green color of this seaweed are easily recognized. *Bryopsis* is found on shallow reef flats, in tidepools, and in lower intertidal habitats of coastlines with low wave action. It grows to heights of 2 to 12 cm.

Caulerpa racemosa

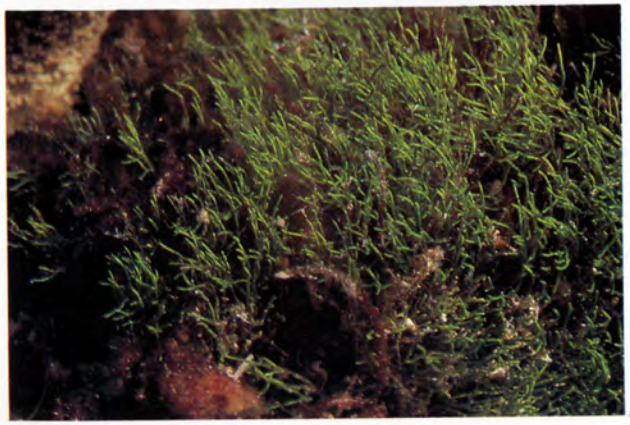
C. racemosa is found in tidepools and on reef flats, where it often forms spreading light green to slightly blueish mats up to 4 cm thick. It has cylindrical prostrate branches from which rhizoids grow and anchor it to the bottom, and upright branches that are covered with small spheres creating a grape-clusterlike appearance.

Caulerpa serrulata

C. serrulata has prostrate branches with anchoring rhizoids and upright branches with a serrated zig-zag appearance. It grows from 2 to 8 cm high, is gray-green in color, and is found in sandy areas on reef flats and in tidepools.

Caulerpa sertularioides

C. sertularioides has upright branches that are featherlike in appearance and prostrate branches with rhizoids that anchor it in the sandy areas of reef flats and tidepools. It is light green in color and from 3 to 10 cm high. This seaweed closely resembles *C. taxifolia* but can be distinguished by the shape of its upright branches, which are round in all parts.



Caulerpa taxifolia

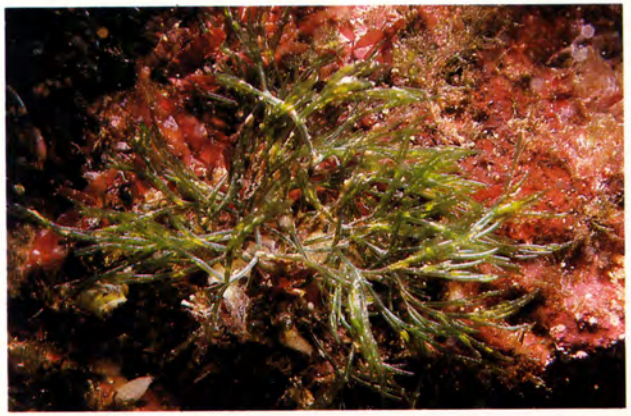
C. taxifolia has featherlike upright branches and prostrate branches with bunches of anchoring rhizoids. It is usually green in color, is 3 to 15 cm high, and grows in the sandy areas of tidepools and reef flats. This seaweed closely resembles *C. sertularioides* except that the upright branches are somewhat flattened with angular edges, giving them a square or rectangular appearance.

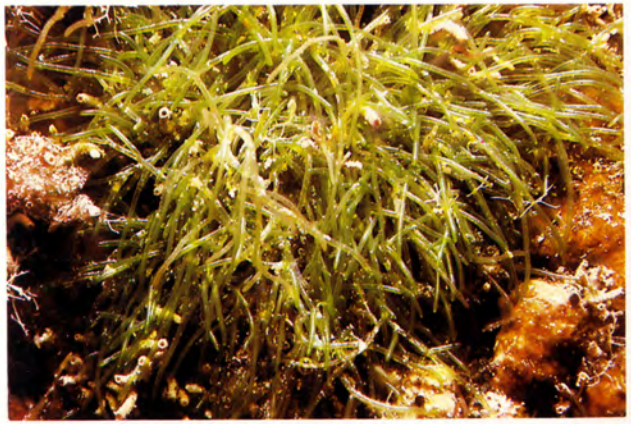
Chaetomorpha antennina

C. antennina forms stiff tufts of unbranched filaments 2 to 15 cm high composed of large cells. Its overall color is grass green, but close examination will reveal alternating green and white bands. The tips become pale green or yellowish when bleached by bright sunlight. This seaweed grows intertidally on rocky coastlines exposed to large breaking waves.

Chlorodesmis hildenbrandtii

C. hildenbrandtii usually forms soft, thick mats from 1 to 5 cm thick that are dark green to yellowish-green in color. It has soft fine branches less than 1 mm in diameter that often trap large amounts of sand. This seaweed grows in tidepools and on reef flats. *C. hildenbrandtii* is one of the few green seaweeds that produces a noticeable odor.





Cladophora fascicularis

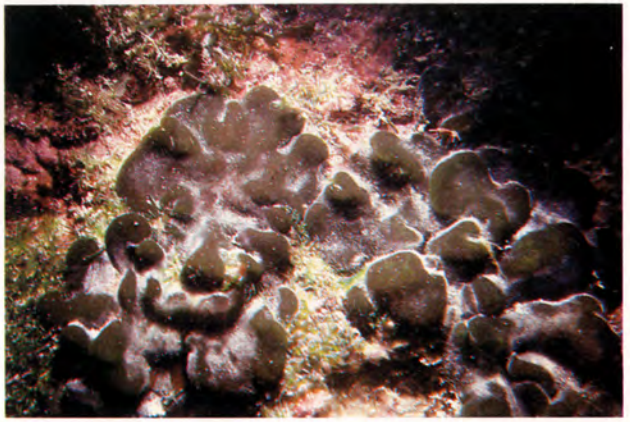
C. fascicularis is a large grass green seaweed that can be from 5 to 50 cm long. It has a bushy appearance produced by many long filaments that have clusters of short branches that all branch in the same direction. This seaweed is found near the zero tide level on protected rocky coastlines and in tidepools.

Cladophora patula

C. patula is a coarse, stiffly branched seaweed that is grass green in color and from 1 to 5 cm high. It has large easily visible cells from 1 to 12 mm long and grows on rocky coastlines in shaded areas, on reef flats, and in between the branches of coral heads at deeper depths.

Cladophoropsis luxurians

C. luxurians forms spreading matlike turfs from 1 to 3 cm thick. The turf is produced by many branches that intertwine, attaching themselves to the bottom wherever they make contact. This seaweed is grass green in color and is commonly found growing on reef flats.



Codium arabicum

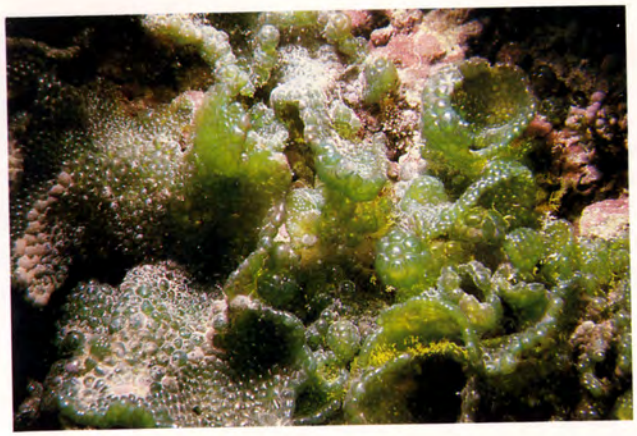
C. arabicum forms very dark green spongy masses from 0.5 to 3 cm thick and up to 15 cm wide. It is characterized by rolling bumps or convolutions on its surface. This seaweed is commonly found in lower intertidal habitats and on reef flats.

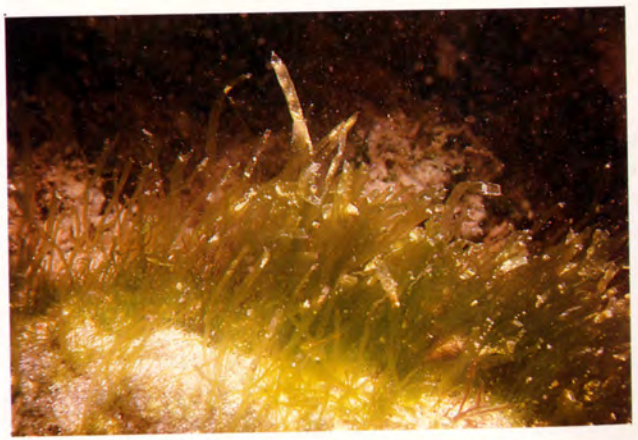
Codium edule *wawae'iole*

C. edule forms spongy, matlike masses made of many intertwined dark green cylindrical branches that are from 3 to 8 mm in diameter. The branches attach to whatever they contact, and it is not uncommon to pick up a specimen and have the bottom covered with pieces of shells, sand, or small rocks. This seaweed is commonly found on reef flats, in lower intertidal habitats, and in tidepools.

Codium reediae *'a'ala'ula*

This dark green seaweed has somewhat flattened branches from 1 to 2 cm wide that are mostly branched in the same plane. It is upright, being attached to the bottom in only one place. *C. reediae* grows in fairly calm water habitats, such as deep tidepools, and on deep reef flats, where it reaches 10 cm.





Dictyosphaeria cavernosa

Because of its large round cells, *D. cavernosa* is frequently called the "green bubble alga." When it is small it is a hollow sphere, but as it grows it ruptures, becoming convoluted and cup shaped. This seaweed is grass green in color, and often forms extensive mats from 1 to 10 cm thick over large areas on shallow reef flats. It can also be found in tidepools and at deeper depths.

Dictyosphaeria versluysii

D. versluysii also has bubblelike cells, but unlike *D. cavernosa* it is completely solid in the middle and always remains rounded. Grass green or sometimes slightly bluish in color, from 1 to 2 cm high and 1 to 5 cm wide, this seaweed is commonly found on reef flats and in tidepools.

Enteromorpha sp. *'ele'ele*

Enteromorpha characteristically consists of a flattened hollow tube that may be branched or unbranched, and is grass green in color. It can be from 1 to 10 mm wide and from 3 to 20 cm long. This seaweed can tolerate a wide range of salinities, often being found in brackish estuaries and in sandy areas with fresh-water seepage. There are several species of this genus in Hawaii, but they are difficult to tell apart without a microscope.

Halimeda discoidea

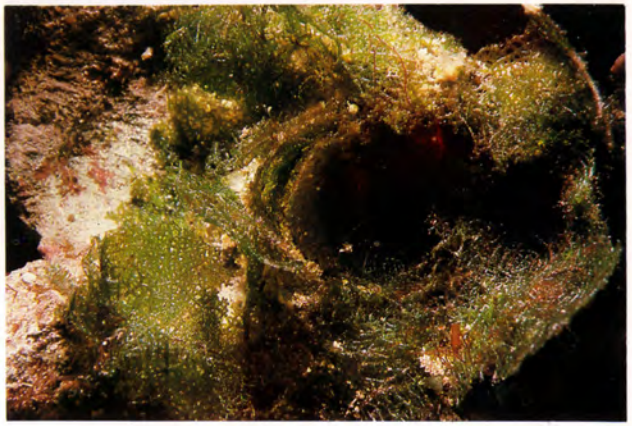
H. discoidea has flat ribless segments 1 to 3 cm wide, and reaches lengths of 15 cm. The outer segments are dark green, but the inner ones are calcified and appear whitish. Due to the nature of its holdfast, this is one of the few seaweeds that is able to anchor itself in deep sand as well as to hard bottoms. It accomplishes this through a sediment-filled bulbous mass of rhizoids that is embedded in the sand. *H. discoidea* is commonly found in sandy areas on reef flats and in deeper water. It is estimated that a significant amount of the sand in some of Hawaii's beaches is the result of the weathering of dead *Halimeda* segments.

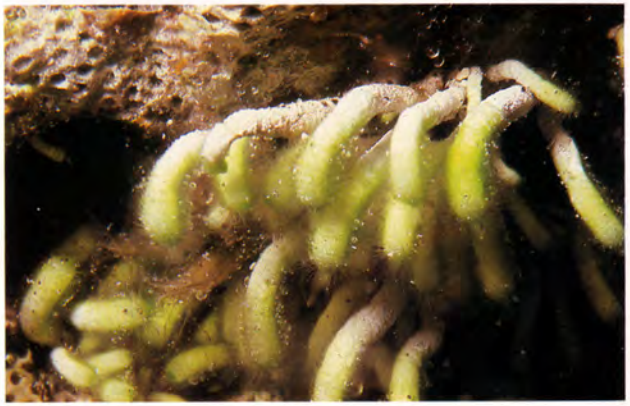
Halimeda opuntia

This calcareous green to whitish seaweed is found in the quiet water of inner reef flats, or more commonly, between the branches of corals in deeper water. *H. opuntia* attaches to the bottom in several places, often has a rib in the middle of its flat 0.5 to 2 cm wide segments, and can reach a length of 30 cm, although it is usually smaller.

Microdictyon japonicum

M. japonicum is a single flattened blade consisting of a meshwork of fine connecting branches. It is grass-green in color, from 1 to 6 cm wide and 1 to 4 cm high. This seaweed can be found in the low intertidal area of rocky coastlines, on reef flats, and in between the branches of corals at deeper depths.





Microdictyon setchellianum

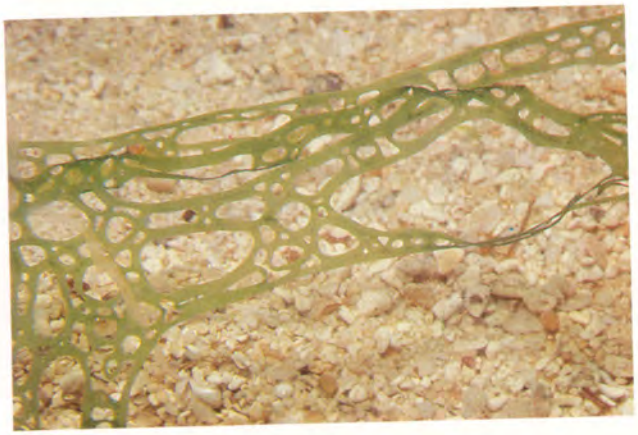
Like *M. japonicum,* this grass green seaweed is also a flattened blade made of a meshwork of branches, but the branches are usually coarser, and several blades are usually arranged in a rosette. Commonly found on reef flats, *M. setchellianum* grows to 8 cm wide and 5 cm high.

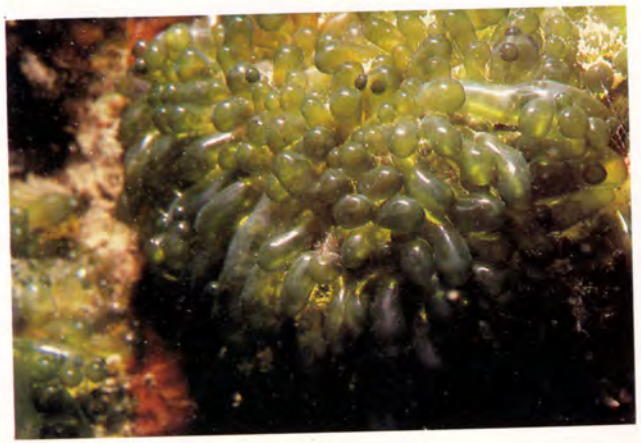
Neomeris annulata

This is surely one of the most distinctive seaweeds in Hawaii. *N. annulata* has a fingerlike form, grows to 4 cm high, and is found in tidepools, on reef flats, and in subtidal habitats, where it often grows in groups in depressions in the rock. The tips of this seaweed are green in color with a fuzzy appearance that is produced by many fine hairs. The lower part is calcified and white.

Siphonocladus tropicus

S. tropicus has many branches that radiate outward from a central stalk, with each branch covered by many small spinelike projections. Reaching a height of 7 cm, it is usually green but often collects fine sediment and may appear whitish. Although not abundant, this seaweed is quickly noticed due to its unusual form. It commonly grows on reef flats.





Ulva fasciata *palahalaha*

U. fasciata, one of the commonest seaweeds in Hawaii, is often called "sea lettuce" in other parts of the world. It is a flat, often twisted blade from 1 to 10 cm wide and 5 to 100 cm long that is grass-green in color. This seaweed is commonly found on intertidal rocks, in tidepools, and on reef flats, and is often abundant in areas that are high in nutrients.

Ulva reticulata

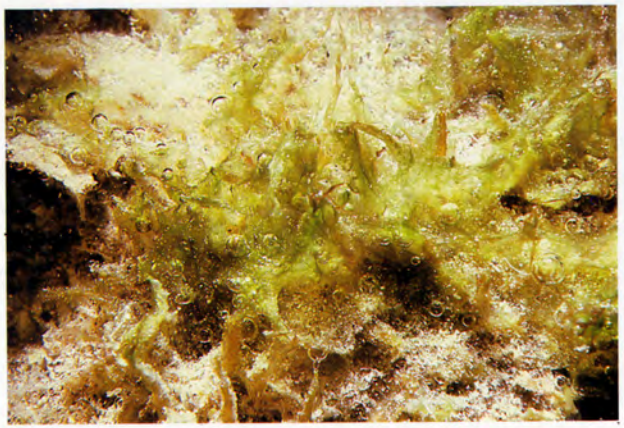
U. reticulata is also a grass green flat blade, which when very small closely resembles *U. fasciata.* As it gets larger, however, cells in the center of the blade produce reproductive spores or gametes and fall out, creating distinctive holes or reticulations. It also separates from its point of attachment and then grows tangled on other algae, reaching lengths up to 3 m, although it is usually much smaller. This seaweed is commonly found on reef flats, where at times it almost completely covers the other seaweeds.

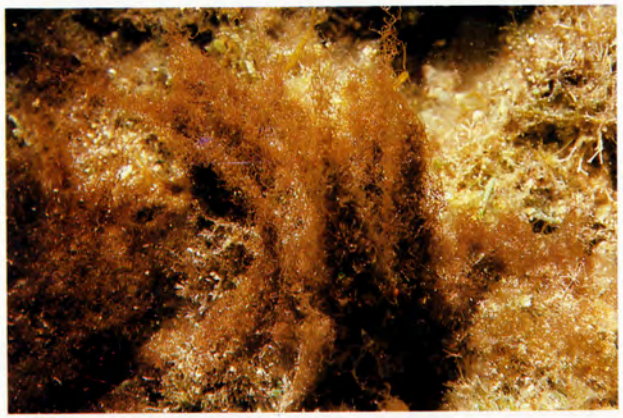
Valonia aegagropila

V. aegagropila is composed of many elongated grass green tubes that usually have only their ends visible. This seaweed forms hemispherical cushions from 2 to 8 cm high and 5 to 15 cm wide, and is found on reef flats or in tidepools, where in some areas it almost completely covers large areas of the bottom.

Valonia ventricosa

This distinctive egg-shaped seaweed is a single liquid-filled sack that can be as large as 5 cm across. Dark to silvery green in color, *V. ventricosa* is found in turfs in lower intertidal habitats along rocky coastlines, in tidepools, on reef flats, and in between the branches of corals at deeper depths.





CYANOPHYTA
(Blue-green Seaweeds)

Hormothamnion enteromorphoides

H. enteromorphoides, usually bright green in color, is formed of delicate wispy filaments which cover patches of sand or grow tangled on other seaweeds. This seaweed is from 2 to 8 cm long and is found in tidepools and on reef flats.

Lyngbya majuscula

This filamentous seaweed is usually black or dark gray in Hawaii, but can be various shades of red, green, or even yellow. *L. majuscula* is usually 5 to 10 cm long and is commonly found tangled in other seaweeds on reef flats, in tidepools, or in deeper subtidal habitats. Strains of this seaweed cause a rash ("swimmers' itch") on the skin of susceptible individuals.

Symploca hydnoides

The claylike texture and unique structure of this seaweed are unmistakable. It grows from 1 to 4 cm high with many upright triangular shoots growing from a common holdfast. The coloration is also distinctive, black to dark gray on the outside and gray to brown on the inside. *S. hydnoides* is found on reef flats and in deeper subtidal habitats.

PHAEOPHYTA
(Brown Seaweeds)

Chnoospora implexa

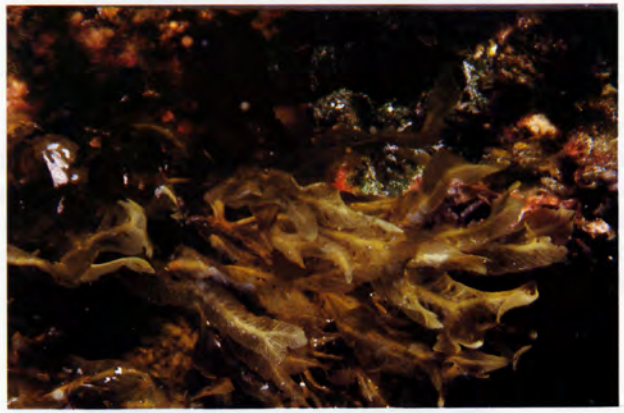
C. implexa forms densely branched cushions as large as 40 cm in diameter, but they are usually smaller. It has branches from 2 to 5 mm in diameter that are solid in the middle, and the color is grayish to light brown. This seaweed resembles *Rosenvingea intricata*, but is usually found growing in tidepools on basalt rock, while *R. intricata* is found on reef flats and in tidepools in limestone rock.

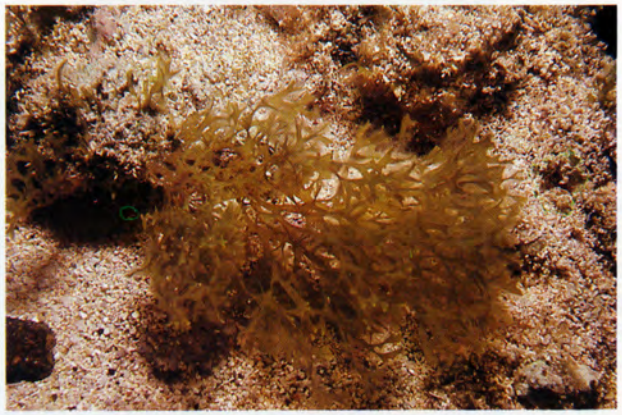
Chnoospora minima

C. minima grows in high intertidal habitats along rocky coastlines where large waves break. It often appears in seasons when high waves strike the islands and then dies back when calmer seas prevail. The color is dark brown and the height varies from 3 to 15 cm. This seaweed often has a fuzzy growth of diatoms near the tips of the branches.

Colpomenia sinuosa *puha*

C. sinuosa is a hollow saclike seaweed that is golden brown in color and can have a smooth or convoluted surface. It can be found in several habitats. When it grows intertidally or on other seaweeds it is usually small, from 1 to 5 cm in diameter, but when it grows in tidepools and on reef flats it is considerably larger, up to 20 cm in diameter.





Dictyopteris australis *lipoa*

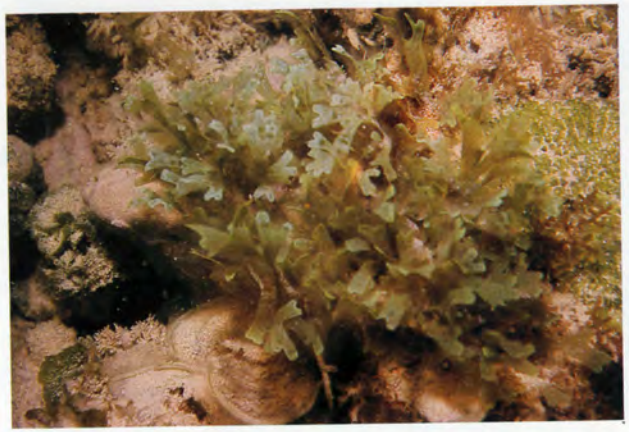
D. australis is an abundant deep water seaweed in Hawaii. It is often found in extensive dense beds outside reef crests at depths of 3 to 20 m, and is also occasionally present on reef flats. The color is brown with dark spots, the size varies from 10 to 40 cm, and the blades are flat, from 1 to 2 cm wide, with a midrib and ruffled margins. This seaweed produces a strong odor, as does *D. plagiogramma.*

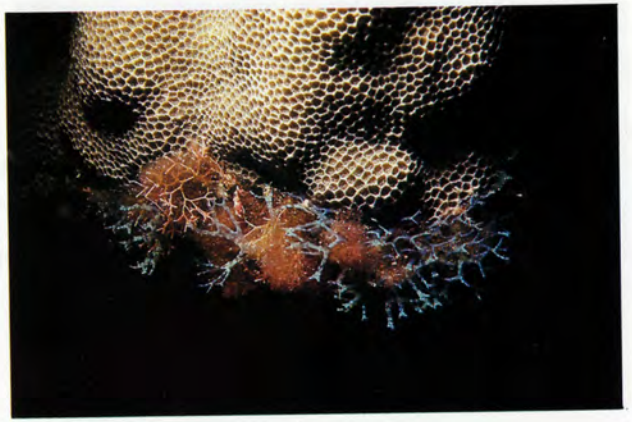
Dictyopteris plagiogramma *lipoa*

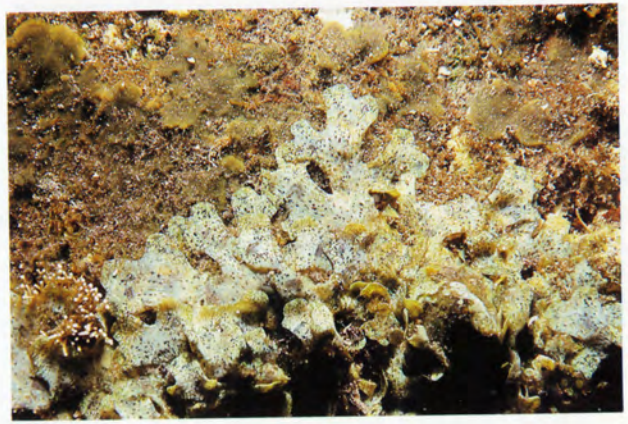
This seaweed is similar to *D. australis* but smaller, from 5 to 20 cm high, and has narrower blades, from 0.5 to 1 cm wide. *D. plagiogramma* is brown and the blades have ruffled margins and a midrib. It is found on rocky shores at about the zero tide level, on reef flats, and outside reef crests in deeper water.

Dictyota acutiloba *alani*

D. acutiloba has flat, spirally twisted blades from 1 to 2 mm wide that branch in a Y pattern and lack a midrib. The size varies from 3 to 20 cm, and the color is light brown. This seaweed is commonly found in tidepools, on reef flats, and in deeper subtidal habitats.







Dictyota bartayresii *alani*

D. bartayresii is light iridescent bluish-green and has branches from 2 to 5 mm wide that have rounded tips and no midrib. This seaweed is erect, from 2 to 10 cm in height, and grows in rocky lower intertidal habitats and on reef flats. This seaweed never has small side branches as does *D. sandvicensis*.

Dictyota divaricata

D. divaricata produces a bright bluish or greenish iridescence. It has pointed untwisted flat branches without midribs that are 0.5 to 3 mm wide. This seaweed reaches a height of 5 cm and is often found growing intertwined with other algae in tidepools, on reef flats, and at deeper depths in between the branches of corals.

Dictyota friabilis

D. friabilis is light bluish-green iridescent with wide flat branches from 3 to 10 mm across that have rounded tips and lack a midrib. This seaweed grows on other algae or rocky bottoms, and is found in tidepools, on reef flats, and in other shallow subtidal habitats.

Dictyota sandvicensis *alani*

D. sandvicensis exhibits a noticeable yellowish-green iridescence. The blades are 2 to 5 mm wide, lack midribs, branch in a Y pattern, are sometimes twisted, and often but not always have many small side branches. This seaweed reaches a height of 12 cm and is common in tidepools and on reef flats.

Endarachne binghamiae

The flat, limp blades of *E. binghamiae* are usually found during winter months high on intertidal rocky shores. This seaweed is light brown, unbranched, and forms small tufts of several blades 2 to 5 mm wide and 5 to 15 cm long growing from a single holdfast.

Gifford breviarticulata *hulu'ilio*

G. breviarticulata is a very common seaweed of rocky coastlines colonizing the very high intertidal habitat. It consists of many tangled fine filaments that form a spongy, ropelike tuft from 1 to 5 cm long. Usually golden brown in color, it may sometimes appear greenish because of microscopic blue-green algae that grow epiphytically on its surfaces.

Hydroclathrus clathratus *poha*

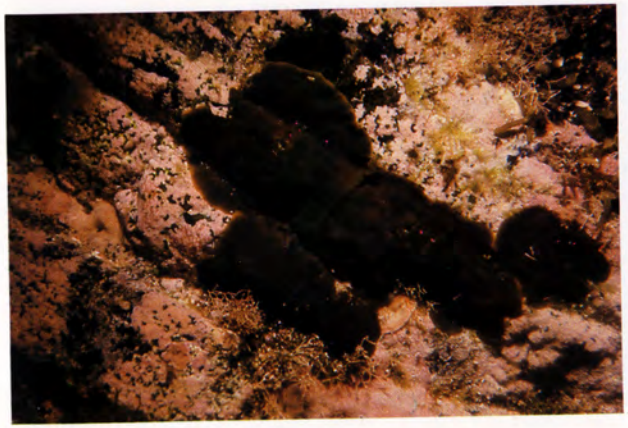
H. clathratus typically forms light-to-olive brown masses that have very distinctive perforations. This seaweed can be up to 30 cm in diameter but is more often smaller. It is commonly found in warm tidepools and on shallow reef flats.

Lobophora variegata

L. variegata is a flat seaweed from 1 to 8 cm across that grows prostrately over rocky substrates but is attached in only a few places. Orange to dark brown with radial markings, it is found in lower intertidal habitats, in tidepools, and on reef flats.

Padina australis

P. australis is a flat seaweed with an in-rolled margin that splits into narrow fan-shaped sections. It is light brown in color and slightly calcified. Attached by a single holdfast, it can be from 5 to 20 cm tall and is found in deep tidepools and on reef flats.



Padina japonica

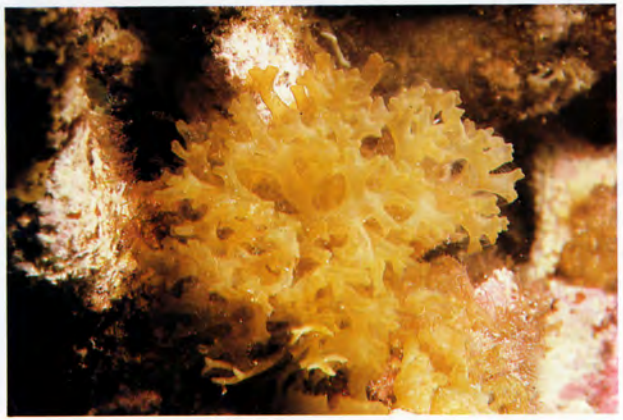
P. japonica is characterized by a flat blade rolled into a circle and an in-rolled margin. The upper surface of the blade is whitish due to the presence of calcium carbonate, while the lower surface, with less calcification, is brownish. This seaweed is very common in shallow tidepools, where it reaches a height of 10 cm, and on reef flats, where it can be 20 cm high.

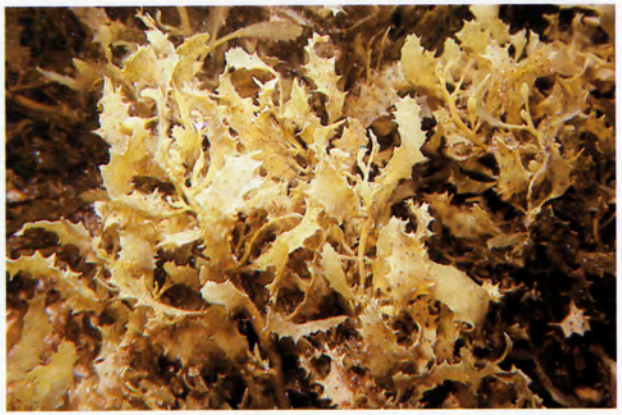
Padina thivyi

P. thivyi has a leathery texture, in-rolled margins, and a whitish gray color due to the presence of calcium carbonate. It usually forms thick mats from 2 to 10 cm thick on reef flats and occasionally in tidepools.

Ralfsia pangoensis

There are several species of *Ralfsia* found in Hawaii. They are dark brown crustose seaweeds that grow radially over rocky bottoms. They adhere firmly to the bottom with only the outer margins free. From 1 to 6 cm in diameter, these seaweeds can be found in almost any tidepool or reef habitat.





Rosenvingea intricata

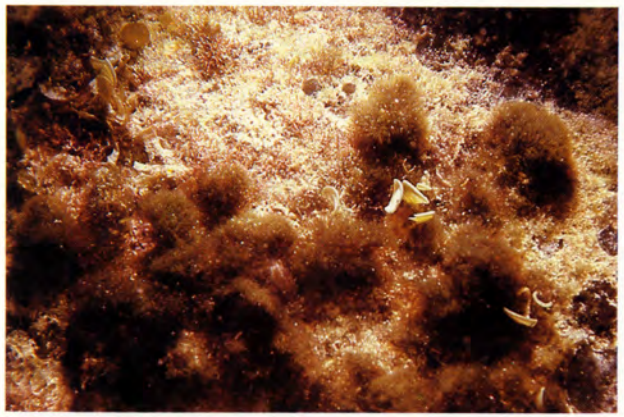
R. intricata forms golden-brown cushions from 3 to 10 cm high and from 5 to 15 cm in diameter. It has round hollow branches from 2 to 5 mm in diameter. This seaweed resembles *Chnoospora implexa*, but is found on reef flats and in tidepools in limestone rocks while *C. implexa* is usually found in basalt tidepools.

Sargassum echinocarpum *kala*

S. echinocarpum is commonly found in wave-swept rocky intertidal habitats, in tidepools, and on reef flats. It has golden to dark brown leaflike blades with a mid-rib and flattened stems. The blades are usually spiny but are sometimes smooth. There are often small inflated gas bladders which have flattened stalks. This seaweed can be from 5 to 70 cm long with blades from 0.5 to 3 cm wide.

Sargassum obtusifolium *kala*

S. obtusifolium is commonly found in tidepools and on reef flats. It has light brown leaflike blades with a midrib, round, smooth main stems, and gas bladders on round smooth stalks, although these are not always present. This seaweed can be from 5 to 50 cm tall and has blades from 0.3 to 2 cm wide.



Sargassum polyphyllum *kala*

S. polyphyllum is found on wave-swept benches, in tidepools, on reef flats, and occasionally at deeper depths. It has many light brown leaflike blades with a midrib, and when present, gas bladders that have leaflike stalks. The main stems have many short spiny projections. This seaweed can be from 5 to 40 cm tall and has blades from 0.5 to 1 cm wide.

Spatoglossum solierii

S. solierii has flat, thin, straplike blades without midribs that are from 5 to 40 cm long and from 1 to 5 cm wide. It is found on deep reef flats at depths of 1 to 5 m and is brown.

Sphacelaria furcigera

S. furcigera is a black fuzzy tuft of filaments that are all approximately the same length. Up to 2 cm tall, it commonly grows on rocky surfaces or larger seaweeds in tidepools and on reef flats.

Stypopodium hawaiiensis

S. hawaiiensis, from 1 to 5 cm high, exhibits a beautiful iridescent blue or green color. It consists of many flat blades that do not have an in-rolled margin as in the similar-appearing species of *Padina*. This seaweed is found on wave-swept benches and reef flats, where its bright coloration makes it easily noticed.

Turbinaria ornata

T. ornata is a stiff, erect seaweed with distinctive angular turbanlike blades and a central stem. Light brown to brown, from 2 to 20 cm tall, it grows on rocky intertidal coastlines, in tidepools, and on reef flats and crests.

RHODOPHYTA
(Red Seaweeds)

Acanthophora spicifera

A. spicifera has solid cylindrical branches from 1 to 3 mm in diameter that are covered with many distinctive small, spinelike branches. It can vary in height from 3 to 20 cm and is abundant on calm, shallow reef flats, in tidepools, and on intertidal rocky benches swept by small waves. This seaweed can be red, brown, or dark green in color, but often turns yellow when exposed to bright sunlight.

Actinotrichia fragilis

A. fragilis is red or yellow with cylindrical branches about 1 mm in diameter that are covered with closely spaced rings of short, dark, stiff hairs. This lightly calcified seaweed is from 2 to 6 cm high and grows in tidepools, on reef flats, and in deeper subtidal habitats.

Ahnfeltia concinna *'aki'aki*

A. concinna is often the highest-growing intertidal seaweed on basalt rock coastlines, where it can form an extensive dense band or be present only in small cracks and crevices. It has tough rubbery cylindrical branches 0.5 to 3 mm in diameter and 2 to 60 cm long. The color is variable; those growing highest are bright yellow, while those growing lowest are dark red.

Amansia glomerata

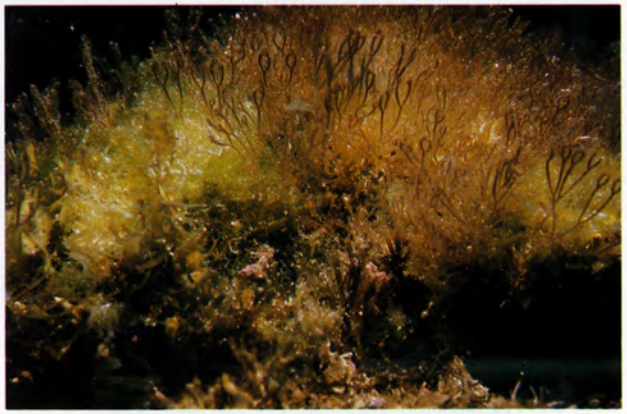
A. glomerata, which grows to 15 cm tall, is bushlike in appearance with a round central stipe and flattened blades from 3 to 7 mm wide. It is dark red, but is often covered with epiphytic crustose coralline seaweeds which give it a pink appearance. This seaweed is widespread, being found in shaded areas of almost any habitat.

Amphiroa fragilissima

A. fragilissima is a heavily calcified seaweed that is very brittle and breaks easily into small pieces. It is pink, has branches less than 1 mm in diameter, and often forms extensive mats 2 to 6 cm thick in shallow tidepools.

Asparagopsis taxiformis *kohu*

A. taxiformis is red to bluish violet in color, has a fluffy appearance, and is shaped like a Christmas tree. This seaweed is 3 to 15 cm high, and commonly grows in shallow subtidal habitats with heavy water motion, such as reef crests, where there are continually breaking waves.



Botryocladia skottsbergii

B. skottsbergii has a unique appearance, resembling rounded balls on short stalks. This seaweed is dark red to dark green, 1 to 3 cm tall, and grows in clusters in shaded places such as overhanging ledges, holes, and crevices on reef flats and in lower intertidal habitats along rocky coastlines.

Centroceras clavulatum

C. clavulatum has Y-shaped branches less than 1 mm in diameter with the final two branches often curving inward, creating a clawlike appearance. It is usually dark red, from 0.5 to 5 cm long, and grows in turfs and mats in lower intertidal habitats, in tidepools, and on reef flats.

Champia sp.

Champia has segmented branches from 1 to 3 mm in diameter that resemble earthworms. It can be red to light pink, but often has a blue or green iridescence. It forms clumps from 2 to 6 cm high and is found on reef flats and in other shallow subtidal habitats, where it grows on rocks or as an epiphyte on larger seaweeds.

Cladymenia pacifica

C. pacifica has flat branches from 2 to 6 mm wide that are iridescent light blue or light green. It varies from 2 to 10 cm in length and is usually found growing on rocky substrata in subtidal habitats below 3 m.

Coelothrix irregularis

C. irregularis has round rubbery elastic branches from 1 to 2 mm in diameter that are very dark red, often with a shiny surface. This seaweed grows on rocks in lower intertidal habitats and on reef flats, where it forms loosely woven mats 5 to 15 cm across.

Corallina sp.

Corallina is a heavily calcified seaweed with main branches consisting of short segments, each of which has a small segment on each side. It is pink, 1 to 5 cm tall, and grows in rocky intertidal habitats, in tidepools, and on reef flats.

Dasyopsis sp.

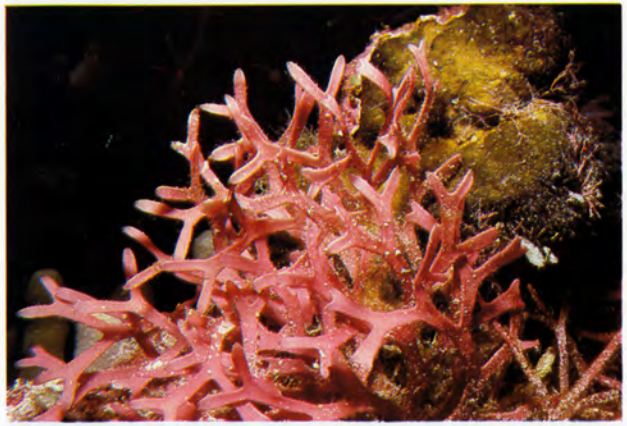
Dasyopsis, a beautiful iridescent blue, green, or violet, is rarely overlooked. This seaweed is from 2 to 8 cm high and is found in tidepools, on reef flats, and in other shallow subtidal habitats. Its branches are covered with many fine branchlets, which produce its characteristic fluffy appearance.

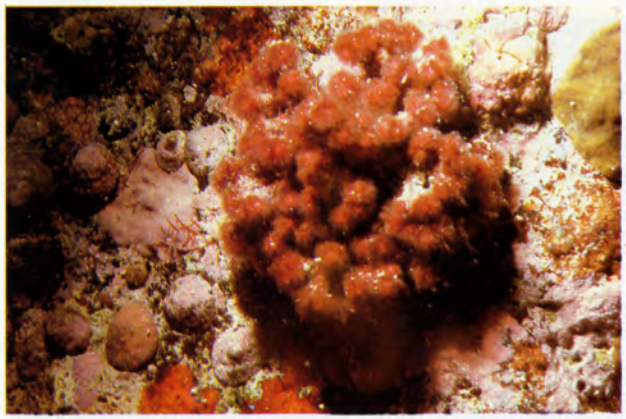
Desmia hornemannii

D. hornemannii produces a distinctive strong odor. It is bright red, from 2 to 6 cm high, and has branches that are rolled back at the tips. This seaweed grows in almost any habitat, from rocky intertidal to inbetween the branches of corals at subtidal depths. It resembles *Plocamium sandvicense,* but its rolled-back branch tips and storng odor are distinctive.

Dotyella hawaiiensis

This beautiful bluish-purple seaweed is usually found growing on the branches of corals in subtidal habitats below 5 m. It has many fine, soft branches and can reach a length of 10 cm.





Galaxaura acuminata

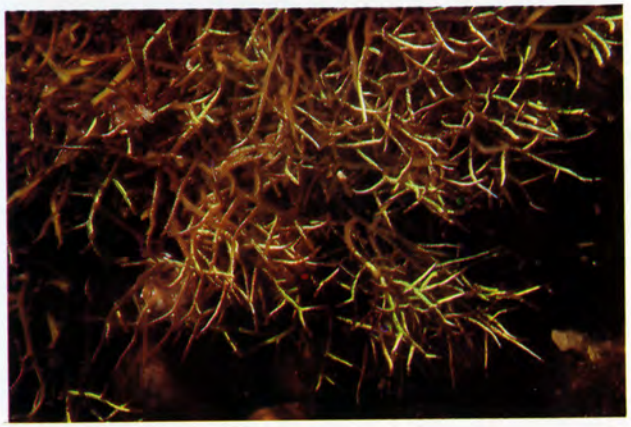
G. acuminata can be found in shaded areas of deep tidepools or at deeper depths, where it often grows between the branches of corals. It has hollow branches, but this is not immediately apparent because they are flattened, from 1 to 4 mm wide. This calcified seaweed is pink to red and grows to 15 cm in length.

Galaxaura fastigiata

G. fastigiata has hollow cylindrical branches 1 to 2 mm in diameter with deep pits in the ends. It is found in tidepools and on reef flats, where it reaches a height of 15 cm. This calcified seaweed is white to pink in color.

Galaxaura filamentosa

G. filamentosa is usually found in tidepools, but is sometimes present on reef flats. It has cylindrical branches 1 to 3 mm in diameter that are covered with fine, soft hairs. The main part of the branch is white or pink, while the hairs are dark red. This calcified seaweed can reach a height of 8 cm.



Galaxaura rugosa

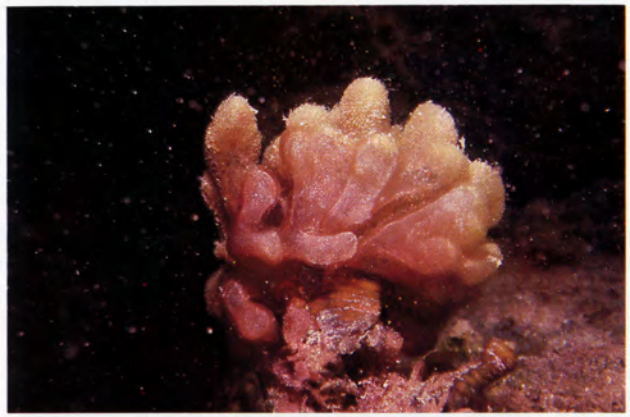
G. rugosa is commonly found growing in tidepools. It has hollow cylindrical branches 1 to 3 mm in diameter with obvious pits in the ends. The color is usually yellow at the tips, turning to red at the base. This lightly calcified seaweed can be from 3 to 8 cm tall.

Gelidiella acerosa

G. acerosa has cylindrical branches about 1 mm in diameter and grows in lower intertidal habitats, in tidepools, and on reef flats, where it intertwines with other seaweeds to form dense turfs. The exposed parts of this seaweed are yellow, while the parts tangled down in the turf are dark red.

Gelidiella machrisiana

G. machrisiana is found in shallow tidepools, where it usually grows in a dense turf with many other different seaweeds. Its small, round branches are less than 1 mm in diameter and reach a length of 3 cm. When present, this seaweed rarely escapes notice, because it is brilliant green, yellow, or bluish iridescent.



Gelidiopsis scoparia

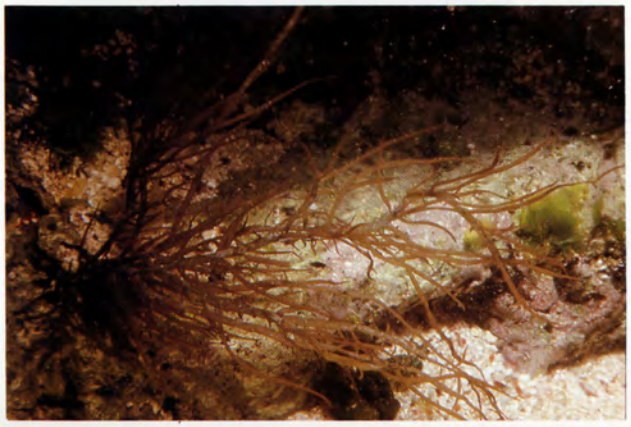
G. scoparia is a tough, wiry seaweed with rounded or flattened branches less than 1 mm across that sometimes become wider and more flattened where branching occurs. The height varies from 2 to 8 cm. This seaweed is dark brownish red in color and grows in intertidal habitats along rocky coastlines. The swellings at the tips of the branches in the picture are reproductive structures and are not present in all specimens.

Gibsmithsia hawaiiensis

The unusual appearance of *G. hawaiiensis* is unmistakable; it has many thick, loose branches from a tough central stalk. The color varies from red to white, and the size from 3 to 12 cm. This seaweed is most often found growing between the branches of coral in water deeper than 5 m, but can occasionally be found on reef flats.

Gracilaria bursapastoris *ogo* (Japanese)

G. bursapastoris is one of the larger red seaweeds in Hawaii, sometimes growing to 60 cm in length. Its branches are cylindrical, from 1 to 4 mm in diameter, and have pointed tips that are long and narrow. This seaweed grows on reef flats and is red, but can be light brown, light green, or almost white in areas with bright sunlight.



Gracilaria coronopifolia *manauea*

G. coronopifolia has solid cylindrical stiff branches from 1 to 4 mm in diameter that have short pointed tips. It is red in color, but often bleaches to pink or white in bright sunlight. This seaweed commonly grows on reef flats, where it is 6 to 20 cm tall, but may occasionally be found in tidepools.

Gracilaria salicornia

G. salicornia has cylindrical branches from 2 to 5 mm in diameter that often but not always have distinctive constrictions. This seaweed grows in tidepools and on reef flats, where it forms mats from 1 to 5 cm thick, by itself or tangled with other seaweeds. The color is bright yellow in sunny areas, turning to greenish brown in shady habitats.

Grateloupia filicina *huluhuluwaena*

G. filicina is a soft, limp seaweed with somewhat flattened branches that can be red, green, brown, or almost black. The size and shape very greatly; from 0.5 to 5 mm wide, from 2 to 30 cm long, with only a few branches or with many branches. This seaweed grows at about the zero tide level on rocky coastlines and on shallow reef flats.

Grateloupia hawaiiana

G. hawaiiana has a flat, branched blade that usually grows from a short cylindrical stipe. It is red to dark red, 3 to 20 cm high, and is found in intertidal habitats along open rocky coastlines or on reef flats.

Grateloupia phuquoensis

G. phuquoensis has flat blades about 1 mm thick and 2 to 4 mm wide that grow from a long stipe that is flattened at the top, but rounded near the holdfast. The color is dark red. This seaweed grows in clumps from 2 to 12 cm high in intertidal habitats along rocky coastlines that are exposed to large breaking waves.

Gymnogongrus sp.

Gymnogongrus has tough stiff branches from 2 to 3 mm in diameter. The color is usually dull red or dark green with lightly colored tips, but the entire seaweed can be bleached by bright sunlight. This seaweed is from 2 to 12 cm long and grows in shaded intertidal and shallow subtidal habitats along rocky coastlines.

Halymenia formosa *lepe'ahina*

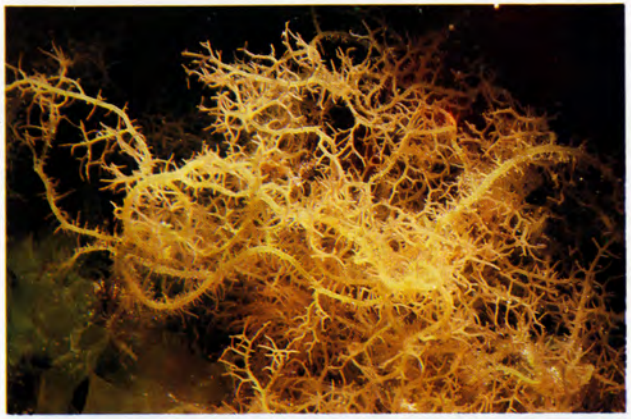
H. formosa is an expanded flat blade from 5 to 30 cm long, with a rough surface and a ruffled fringe that resembles a cock's comb. The color is usually bright red with white areas, but it can be yellowish. This seaweed is found on reef flats and in other subtidal habitats to a depth of 10 m.

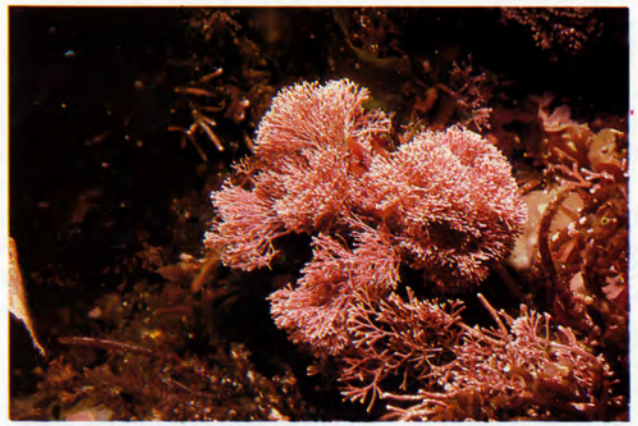
Hydrolithon breviclavium

H. breviclavium can occur as a calcareous crust but more commonly occurs as a pinkish to dull reddish nodule usually smaller than a fist in size. The nodules are smooth surfaced and exhibit an extensive development of small, blunt branches. *H. breviclavium* occurs on reef flats and in deeper water.

Hydrolithon reinboldii

H. reinboldii, characterized by a pale grayish-blue-violet to pale bluish-violet rough-textured large knobbed surface, occurs either as a calcareous crust on dead limestone reef or ranges from small fragments up to fist-sized nodules. Nodules of *H. reinboldii* are formed (as are the nodules of other crustose coralline seaweeds) when the spores of the seaweed settle on and grow over loose reef rubble fragments that are rolled about by waves or surge as the seaweed grows. *H. reinboldii* occurs over the entire reef flat, extending into waters 20 m deep.





Hypnea cervicornis *huna*

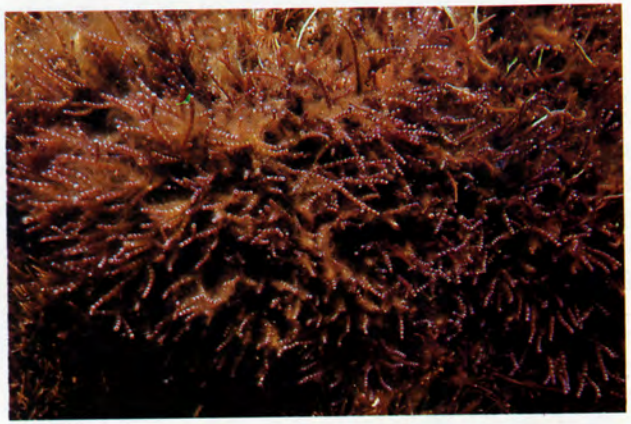
H. cervicornis has rounded main branches from 1 to 3 mm in diameter with short, pointed side branches. The length varies from 3 to 30 cm. This seaweed grows in tidepools and on shallow reef flats, where it varies in color from bright yellow in areas with bright sunlight to dark red in shaded areas. It may sometimes be epiphytic on larger seaweeds.

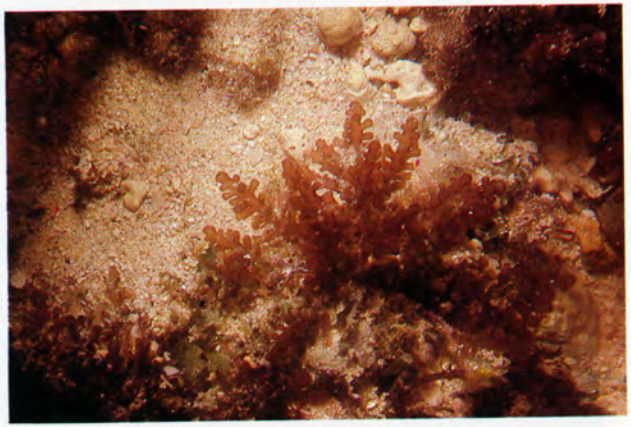
Hypnea chordacea

H. chordacea has cylindrical main branches that are often completely covered by short spinelike branches, which produce a Christmas-tree-like form. It is from 2 to 8 cm tall and can be dark red, green, or brown. This seaweed grows tangled with other seaweeds in intertidal habitats along rocky coastlines.

Jania sp.

Jania has calcified brittle branches less than 0.5 mm in diameter. It is pink to white in color and varies from 0.3 to 2 cm in length. Close examination of almost any habitat will reveal the presence of this seaweed.





Laurencia nidifica *mane'one'o*

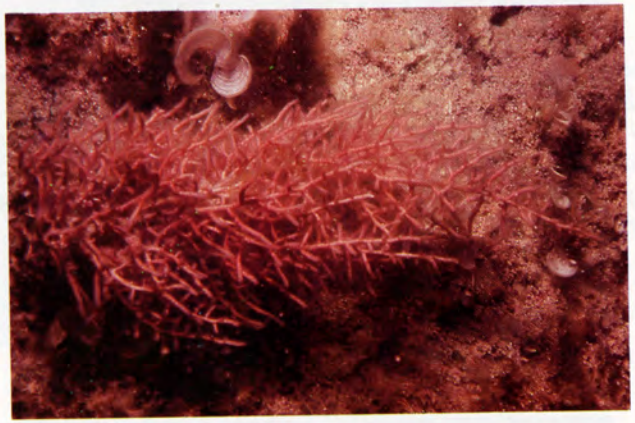
L. nidifica is commonly found on reef flats and in lower intertidal habitats along rocky coastlines, although it can sometimes be found at greater depths. It has round main branches from 1 to 2 mm in diameter that have many side branches growing out in all directions. The tips of the branches have pits in them from whcih many colorless hairs grow. This seaweed can be from 2 to 20 cm long with highly variable coloration, from bright green in sunny intertidal habitats to dark red in shaded subtidal habitats.

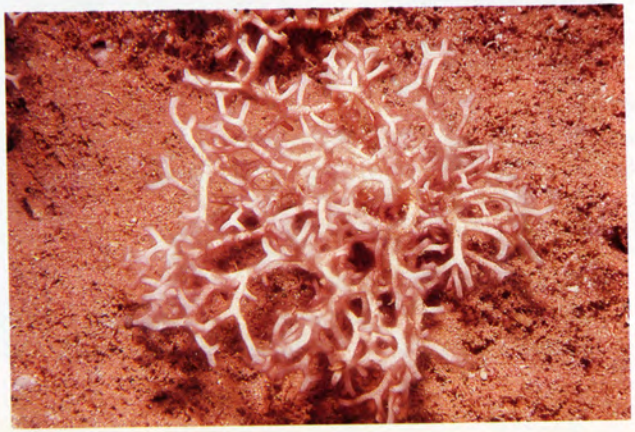
Laurencia obtusa

L. obtusa has cylindrical branches less than 1 mm in diameter that have very few side branches. It is reddish-green in overall appearance, but close examination will reveal distinctive colored banding and the presence of small, fine hairs at the branch tips. This seaweed grows in rocky tidepools, where it forms dense mats from 0.5 to 3 cm thick.

Laurencia succisa *lipe'epe'e*

L. succisa is usually found on reef flats, often in cracks or under larger seaweeds, where it reaches a height of 5 cm. Its main branches are slightly flattened with two opposite rows of short side branches with pits at their ends. This seaweed is dark red or dark green and may be slightly iridescent.





Liagora maxima

The branches of *L. maxima* are red and gooey at the tips but become white and calcified further back, often with a chalky cracked surface. This seaweed grows from 3 to 20 cm high with branches from 1 to 3 mm in diameter. It is usually found on large boulders in water from 0.5 to 5 m deep, but sometimes grows intertidally.

Liagora papenfussii

L. papenfussii has branches from 1 to 3 mm in diameter that are gooey at the tips, but are calcified and firm further back. The color is pink and the size varies from 5 to 30 cm. This seaweed grows on wave-swept benches and on shallow reef flats.

Liagora tetrasporifera

L. tetrasporifera has white lightly calcified branches about 1 mm diameter that are gooey at the tips. It varies in height from 2 to 8 cm. This seaweed is usually found on reef flats but also occurs in deeper subtidal habitats to 10 m and in tidepools.

Lithophyllum kotschyanum

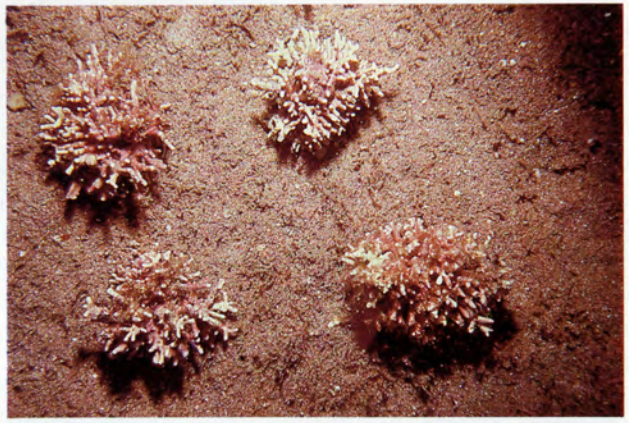
L. kotschyanum appears as a stoutly branched pinkish to purplish dense headlike growth up to 10 cm high and 15 cm wide. Branches of this seaweed tend to be broadened and flattened, never pointed, often fusing near the tips. *L. kotschyanum* is most commonly found on the *Porolithon*-ridge, on reef flats, and in deeper water.

Martensia fragilis

M. fragilis is a flat seaweed that may be completely solid and smooth or divided into a fine lacelike network on the outer portion. It is from 1 to 8 cm high and is common in tidepools and on reef flats, but may also be found in lower intertidal habitats and in deeper water. The color is highly variable; it is usually a shade of blue or green with light spots, but it may also be all or part reddish orange or yellow.

Mesophyllum mesomorphum

M. mesomorphum forms dark-to-purplish-red, thin, overlapping brittle crusts that are often roselike in appearance. This crustose coralline seaweed is most frequently found in shaded rocky intertidal habitats such as caves and holes.



Neogoniolithon frutescens

N. frutescens, pinkish in color, commonly forms 2 to 3 cm long small-diametered (1 to 2 mm) highly branched nodules, but may occur less commonly as a crust. This crustose coralline seaweed usually occurs just shoreward of the reef crest or in deeper waters.

Peyssonellia rubra

P. rubra is a red to maroon crustose seaweed that is calcified on its lower surface. Its edges are free, but elsewhere it is firmly attached to the bottom. This seaweed, common in most subtidal habitats, grows on dead coral, rubble, and other hard surfaces.

Plocamium sandvicense

P. sandvicense is bright red and has branches with inwardly curving tips. It is from 2 to 8 cm long and grows on reef flats and on rocky coastlines just below the zero tide level. This seaweed resembles *Desmia hornemannii* but does not produce a strong odor and has branch tips that are curved inward, not rolled back.

Porolithon gardineri

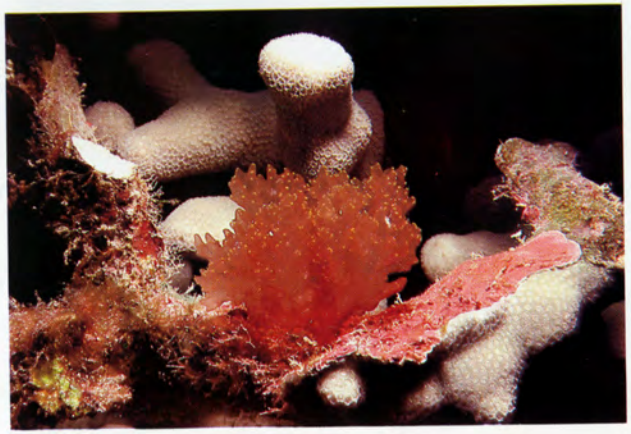
P. gardineri forms pinkish calcareous crusts or much branched hemispherical-shaped heads from 10 to 30 cm across (or larger). The branch tips of *P. gardineri* may be rounded or fused and somewhat flattened, but some pointed branch tips are usually present. *P. gardineri* occurs on the *Porolithon* ridge, in other areas of turbulent surf, or in crevices with strong currents.

Porolithon onkodes

P. onkodes forms extensive pinkish to somewhat purplish chalky crusts in intertidal areas exposed to surf action. Due to its tolerance of strong sunlight and dessication and its crustose nature it is extremely successful in occupying high-wave-energy intertidal habitats such as the basalt coastlines of open coasts or intertidal reef crests. *P. onkodes* performs a critical role in the formation and maintenance of the biotic reefs of Hawaii, as well as atoll land forms, by providing an actively growing reef rim, allowing consolidation and cementation of reef material to occur in the protected areas shoreward of the *Porolithon* ridge.

Porphyra sp. *pahe'e*

Porphyra is a very thin, flat seaweed that grows in slippery clumps very high in wave-splashed intertidal habitats along rocky coastlines. The color is red to yellowish brown and the size is from 2 to 15 cm long and 1 to 3 cm wide. This seaweed is very seasonal, appearing during winter months and disappearing by late spring.



Predaea weldii

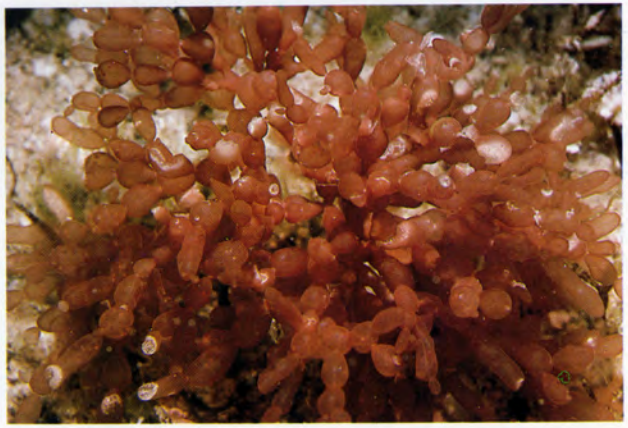
P. weldii is found in subtidal habitats, where it grows between the branches of corals, reaching a length of 5 cm. It is extremely soft and gooey, turning into a shapeless blob when out of the water. Although not usually abundant, this seaweed is quickly noticed because the tips of its branches are fluorescent red.

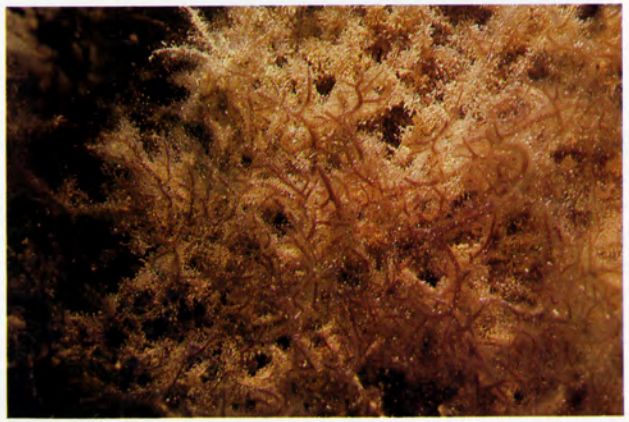
Pterocladia capillacea

P. capillacea often forms an extensive band around the zero tide level in areas exposed to breaking waves. It can be found on basalt coastlines or on the outer edges of reef crests. The color is dark red, but it can appear pink because of crustose coralline seaweeds that grow epiphytically on its surface. The size varies from 2 to 25 cm but is usually around 10.

Pterocladia caerulescens

P. caerulescens is commonly found in tidepools and on reef flats, but can easily be overlooked because of its dark green to blackish color and its habit of growing intertwined with other seaweeds in dense turfs. This seaweed is usually around 2 cm high but can vary from 1 to 8 cm.





Scinaia hormoides

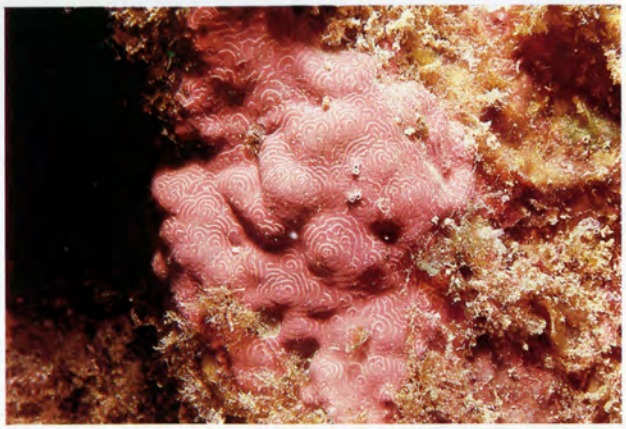
S. hormoides has branches from 3 to 7 mm in diameter with very distinctive regular constrictions which give it the appearance of chains of elongated spheres. The height varies from 5 to 15 cm, the color is pink to red, and it grows in subtidal habitats below 3 m.

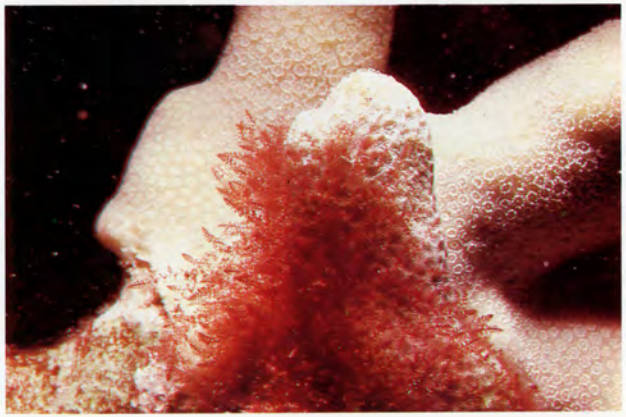
Sporolithon erythraeum

S. erythraeum is characterized by a smooth and glazed maroon to greenish surface with large knoblike structures. *S. erythraeum* may occur as a thick crust or as various-sized nodules. In low-light habitats or on the undersides of nodules it appears maroonish but in stronger light, as on the upper surfaces of nodules, it is greenish. *S. erythraeum*, distributed over the reef flat, is one of the most improtant crustose coralline seaweeds, contributing through its cementing action to the consolidation of various loose reef materials into reef limestone. *S. erythraeum* may also be found in tidepools.

Spyridia filamentosa

S. filamentosa has branches from 0.5 to 2 mm in diameter that are covered with many soft, fine, short branches that create a fuzzy appearance. It is red to almost white, but often traps fine sediment that can make it appear many different colors. This seaweed is usually found in calm inner areas of reef flats where it forms soft, thick mats up to 20 cm thick that can cover large areas of the bottom, but it can also be found at deeper depths.





Tenarea tessellatum

T. tessellatum forms elaborate, spirally sculptured, slightly glazed calcareous crusts or nodules that are pink to pale purple in color. Interestingly, the sculptured spirals may turn either clockwise or counter clockwise. *T. tessellatum*, easily recognized by its distinctive spirals, is most commonly found at depths of about 10 m, but may occasionally be found on reef flats.

Tolypiocladia glomerulata

T. glomerulata forms loose mats from 0.3 to 1 cm thick on rubble and coral heads in subtidal habitats. Its main branches are small, less than 0.5 mm in diameter, and have many short branches growing out from all sides. In deeper water this seaweed is dark red, but in shallow water it can be pale red to almost white.

Trichogloea requienii

T. requienii has slippery round branches that are extremely gooey throughout their entire length. The branches are mostly from 3 to 6 mm in diameter and the height varies from 5 to 40 cm. This light pink, slightly calcified seaweed grows on reef flats and in deeper subtidal habitats to 10 m, where it can be observed flowing back and forth in the moving water.

Wrangelia penicillata

W. penicillata has soft branches that flow with the current and are covered with soft, fine hairs. Its color is variable; red, brown, yellow, or green. This seaweed forms bushy clumps from 3 to 15 cm high on rocks or pieces of dead coral at depths of 0 to 5 m in habitats with moderate water flow, such as on reef flats and just outside the surf zone.

USES OF HAWAIIAN SEAWEEDS

Seaweeds have long been and still are commonly used as food in Hawaii. It is envisioned that their future use and value in industry and as food for animal aquaculture will far exceed that of human consumption.

Historically, Polynesian cultures have utilized seaweeds as a staple food resource. The ancient Hawaiians developed the most extensive use of seaweeds, or "limu," in their diets of any known culture, and utilized various seaweeds in certain rituals and ceremonies as well. Much of the information concerning the uses and names of limu utilized by the Hawaiians has unfortunately been lost over time. Indeed, the distinguished phycologist (one who studies seaweeds), William Albert Setchell, writing in 1905, observed that the younger Hawaiian generation of that day had either forgotten most of the limu names or applied them erroneously. Only the older women and fishermen retained the considerable and discriminating knowledge of limu that the Hawaiians once possessed. Also, most of the scientific literature of that era had many of the seaweeds inaccurately identified or incorrectly named. It is now thought that there were probably sixty or so edible seaweeds variously used by the Hawaiians, although the number of commonly used limu has now dwindled to around twenty, with fewer than ten commonly found in local fish markets.

In this book we have indicated the Hawaiian name of a limu only where the name can be definitely associated with the correct scientific binomial. Hopefully, the other photographs in this book can be used by those who still retain some of the remaining undocumented knowledge of Hawaiian uses of limu. In this way the propagation of a valuable aspect of Hawaiiana may be furthered.

Ancient as well as present-day preparation of limu begins with harvesting at low tides. The initial cleaning of the limu, during which all attached animals, coral, sand, and other seaweeds are removed, takes place at the shore. A second, more complete cleaning occurs later when those limu that do not deteriorate in fresh-water are rinsed thoroughly. The fresh limu is then variously chopped, pounded, soaked overnight in fresh or salt water, or, as in the preparation of limu manauea or ogo, blanched with hot water until it just turns green. Most limu is eaten raw and depending upon your taste, may be prepared "Hawaiian style" or according to Japanese, Filipino, or Korean recipes, some of which are included at the end of this section.

Over the years, perhaps associated with the various immigrations to Hawaii, some usable and some bothersome new seaweeds have appeared in the islands. Whether they managed to arrive here as a result of their natural reproductive and distributive mechanisms, hitchhiked on the hulls of ships, or were otherwise accidentally or purposely introduced is not known, as a reliable record of Hawaii's seaweed flora did not begin to be compiled until around 1950. This research is on-going and with new investigative tools, such as SCUBA diving, many new additions not previously known to the Hawaiian seaweed flora have been added. It is known, however, that certain species such as *Gracilaria bursapastoris* ("ogo") and *Acanthophora spicifera* have appeared here recently (since 1900) and have become firmly established in Hawaiian seaweed communities. *G. bursapastoris* is perhaps now the most widely used edible seaweed in Hawaii in terms of amount harvested and popular use. *A. spicifera*, on the other hand, is a newcomer that is not useful and has displaced many of the algal species previously inhabiting Hawaiian reef flats.

Hawaii's utilization of seaweeds has the potential of undergoing a transition from a "wild harvest" food resource to one of planned seaweed farming. Several seaweeds presently occurring in Hawaii, i.e., *Pterocladia capillacea*, *Ahnfeltia concinna*, *Gelidium pluma*, *Gracilaria* sp., *Hypnea* sp., and *Sargassum* sp., produce gels that are widely used in the preparation of pharmaceuticals, dairy products, cosmetics, paints, textiles, and industrial processes. Hawaii's potential use of these seaweeds as well as introductions of other usable seaweeds is great, but many problems such as the management of coastal growing areas (ponds and reef flats), control of introductions, and labor and development costs will have to be overcome if Hawaii is to capitalize on and realize the potential of marine agronomy.

LIMU RECIPES

HAWAIIAN *

Poki

Limu manauea, limu huluhuluwaena, limu lipe'epe'e, limu mane'one'o, or ogo.

Cube raw fish (ahi, aku) into 2 to 3 cm (1 in) or smaller squares. Add Hawaiian salt to taste. Chop limu into .5-1 cm (¼-½ in) pieces, adding it to salted raw fish, and mix with hands. Serve cold.

The same ingredients may be used equally well with raw opihi.

Limu 'ele'ele

Clean well in fresh-water. Drain. Add Hawaiian salt. Refrigerate in container (or keep at room temperature if stronger flavor is desired) overnight before eating.

Limu palahalaha

Clean well in fresh-water. Chop into pieces. Mix with salted raw fish or other limu (huluhuluwaena).

Limu wawae'iole

Clean well in fresh-water. Chop or pound the limu and mix with Hawaiian salt. Add chili pepper, raw cleaned sea cucumber, sea urchin gonads, raw octopus, or other limu.

Limu lipoa

Chop or pound young blades of limu. Salt lightly and refrigerate. A good dish to accompany uhu, raw octopus, or raw fish liver.

Limu kala

Chop or grind young blades. Salt and refrigerate. Use as a minor addition to other limu, in soups, or in stuffing for baked fish.

Limu pahe'e

Cut into small pieces, salt lightly, and let stand for a few hours before eating.

Limu kohu

Clean well. Soak in fresh-water for half a day to overnight. Salt lightly, pound, and roll into balls.

Limu manauea

Clean and rinse well, removing all epiphytes. Chop into small .5-1 cm (¼-½ in) pieces. Eat with fish or meat or add to chicken stew with grated coconut. To store, salt lightly and refrigerate.

Limu huluhuluwaena

Clean well and rinse. Chop into fine pieces, and salt lightly. Add chopped chili pepper and limu palahalaha. Eat with ake (raw liver) and he'e (octopus).

Limu 'aki'aki

Clean and wash well. Chop into 1 to 2.5 cm (½ to 1 in) pieces. Add to raw salted fish or opihi (as in poki). May be added to chicken or fish baked in the imu.

* For a more detailed treatment of Hawaiian uses of limu, see: Abbott and Williamson. 1974. Limu: An Ethnobotanical Study of Some Edible Hawaiian Seaweeds. Pacific Tropical Botanical Garden, Lawai, Kauai. 21 pp.

JAPANESE

Limu manauea or ogo

½ kg (1 lb) limu manauea or ogo cleaned and blanched and mixed with any one of the following sauces. Serve cold.

Vinegar Sauce
15 ml (1 tbsp) sugar
2.5 ml (½ tsp) salt
120 ml (½ c) vinegar
2.5 ml (½ tsp) MSG

Miso Sauce
60 ml (¼ c) miso
30 ml (2 tbsp) vinegar
30 ml (2 tbsp) sugar
2.5 ml (½ tsp) MSG

Shoyu Sauce
120 ml (½ c) shoyu
30 ml (2 tbsp) sugar
80 ml (1/3 c) rice vinegar
1 clove chopped garlic

Mix ingredients and set for a few hours. Serve cold. *Variation:* Soak limu in Hawaiian-salted water for about one hour or longer; remove and rinse well. Add shoyu sauce and refrigerate for two or more hours before eating.

Limu lepe'ahina

½ kg (1 lb) limu lepe'ahina
60 ml (¼ c) shoyu
45 ml (3 tbsp) rice vinegar or lemon juice
5 ml (1 tsp) sugar

Mix ingredients and add to chopped limu just before serving.

Limu wawae'iole or limu a'ala'ula

½ kg (1 lb) limu wawae'iole or a'ala'ula
180 ml (3/4 c) (or more) teriyaki sauce
23 ml (1½ tbsp) roasted sesame seeds
120 ml (½ c) chopped green onion

Clean limu well in fresh water and drain. Chop limu into 1 to 2 cm (½ to 1 in) pieces and mix with teriyaki sauce, chopped onions, and sesame seeds. Let stand for one hour and serve cold.

KOREAN

Limu manauea or ogo

1 kg (2 lb)
limu manauea or ogo chopped into 3 to 8 cm (1 to 3 in) pieces
handful of coarse Hawaiian salt
2 cloves garlic (chopped) per 950 ml (1 qt) of wilted seaweed
240 ml (½ c) chopped onions
chili pepper, chopped, or 2.5 ml (½ tsp) cayenne (to taste)
2.5 ml (½ tsp) paprika

Wash and clean the limu. Salt and wilt by standing overnight. Drain liquid. Add garlic, onion, chili pepper, and paprika. Pack tightly in jars, seal, and refrigerate. Limu wawae'iole, palahalaha, and huluhuluwaena may be added in small quantities with the manauea or ogo.

Limu manauea or ogo

½ kg (1 lb) limu manauea or ogo, chopped into 3 to 8 cm (1 to 3 in) pieces
240 ml (1 c) rice vinegar or to taste
120 ml (½ c) shoyu
15 ml (1 tbsp) sesame oil or to taste
15-30 ml (1-2 tbsp) roasted sesame seeds
30 ml (2 tbsp) brown or white sugar
30 ml (2 tbsp) mirin
"Ko Choo Jung" hot sauce to taste
chili pepper to taste
chopped garlic to taste

Clean limu well; pour boiling water over limu until color just turns greenish. Mix ingredients together. Add limu to mixture. For best results refrigerate overnight.

Limu manauea or ogo

½ kg (1 lb) limu manauea or ogo chopped
120 ml (½ c) shoyu
60 ml (¼ c) red wine vinegar
10 ml (2 tsp) sugar
1 ml (¼ tsp) MSG
chili pepper or Tabasco sauce to taste

Clean limu; pour boiling water over limu until color just turns greenish. Mix ingredients together, add limu.

FILIPINO

Limu wawae'iole or limu manauea

720 ml (3 c) packed limu wawae'iole or manauea
4 large tomatoes
5 ml (1 tsp) salt
chopped green onions to taste
chopped fresh ginger to taste
30 ml (2 tbsp) shoyu

Wash and clean seaweed. Pour boiling water over cleaned seaweed, drain well. Chop or mash tomatoes and add to seaweed. Add remaining ingredients. Serve cold.

Guso (limu) salad (Ilocano style)

½ kg (1 lb) or 720 ml (3 c) packed guso
960 ml (4 c) boiling water
4 large tomatoes
5 ml (1 tsp) salt
chopped green onions to taste
chopped fresh ginger to taste
30 ml (2 tbsp) shoyu

Wash and clean seaweed. Pour boiling water over cleaned seaweed, drain well. Chop or mash tomatoes and add to guso. Add remaining ingredients. Serve cold.

MISCELLANEOUS

Limu palahalaha

Boil well (until tender) in water, adding vegetables, tofu, pork, chicken, beef, or fish and spices to make a light soup.

COLLECTION AND PRESERVATION OF SEAWEEDS

Seaweed pressings are attractive and their use is limited only by an individual's creativity. In addition to a scientific herbarium collection, pressed seaweeds are commonly used as decoration on stationery and greeting cards or as framed wall hangings.

When collecting seaweeds remember to practice good conservation techniques. For example, harvest only what is needed for your specimens or recipes. More often than not, collectors harvest more seaweed than they can readily use and the excess is wastefully discarded. If you cannot tend to your seaweed soon after collecting, you may keep it fairly fresh by placing it in a container or plastic bag; be sure to drain out all of the water. Place the tightly closed container or bag in a refrigerator. If you drain all the water out and refrigerate the seaweed, it will stay usable for up to two or three weeks. If the water is not drained, the seaweeds will begin to decompose and start to smell. When collecting, also remember to always leave enough seaweed so that it may grow back. Harvesting all of one kind of a seaweed in an area will also prevent that seaweed from reproducing; the next time you want to harvest at your favorite collecting place the seaweed will not be there.

To press seaweeds, begin by collecting fresh specimens. Clean and rinse the seaweed well, removing all other attached seaweeds, animals, rocks, shells, and sand. Fresh-water can be used for all except delicate red seaweeds, which will lose their water soluble pigments. There are two types of seaweeds to consider when pressing, those that will stick to herbarium or high quality rag paper and those that will not. Through experience you will be able to determine which seaweeds will stick and which will not.

For seaweeds that will stick to the mounting paper, float the cleaned seaweed over a sheet of paper that is completely immersed in a slightly inclined shallow tray or dish (Figure 7). Arrange the seaweed on the paper and carefully slide the mounting paper up the inclined tray. A baster and forceps can be used to separate the fine portions of a delicate seaweed or to remove debris from the paper. Once you have arranged the specimen to your artistic satisfaction, place it in the fold of a single page of newspaper (Figure 8).

After placing the specimen in the newspaper, cover it (figure 9) with cotton sheeting, unbleached muslin, paper towels, or waxed paper so that the specimen will stick only to the mounting paper. (Depending on the

stickiness of the seaweed, one type of covering will be more successful than the others – with a little expereince you will be able to determine which one will work best for a particular seaweed.) Once the covering is in place, close the newspaper sheet (figure 10), and alternate the specimens between several sheets of dry newspaper and corrugated cardboard (figure 11). If available, commercially made drying felts and cardboard ventilators should be used in place of newspaper and corrugated cardboards. Coarse, wiry, or stony seaweeds usually will not stick to paper and are best pressed directly between newspaper layers and then glued to the mounting paper with white glue.

After the specimens have been arranged as in figure 11, place a board on the top and bottom, and apply moderate even pressure with rocks, sand bags, or straps. The specimens should be placed in a warm, dry place and the newspaper or drying felts should be changed once a day until the specimens are dry. This will take from two to ten days depending on the seaweed being pressed. Heating the specimens usually produces uneven drying and poor-looking pressings and is not recommended. When the specimens are removed from the press they can be glued down with a small amount of white glue if they are not completely adhered to the mounting paper. The specimens will retain their colors longer if they are kept out of strong light.

If you are interested in establishing a collection of seaweeds, a well-kept collection notebook and accurate labels are vital. The information recorded in your notebook for each specimen should include a description of the habitat in which the specimen was found (i.e., substrata type, intertidal height or subtidal depth, wave or surf conditions, and anything else you think is important), the exact location of the collection, the date, and a collection number. When pressing specimens, it is a good idea to put the collection number in the lower right corner of the mounting paper to prevent confusion in labeling of your specimens. After the specimen has been properly mounted, a label is customarily placed in the lower right-hand corner of the mounting paper. The label should include the information from your notebook and who determined the identity of the specimen. A representative label style is shown in figure 12.

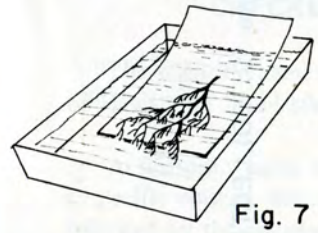


Fig. 7

Fig. 8

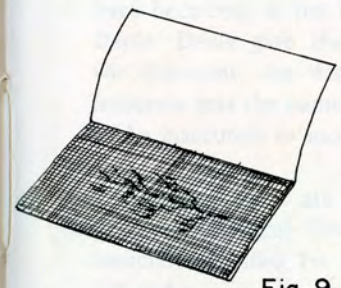


Fig. 9

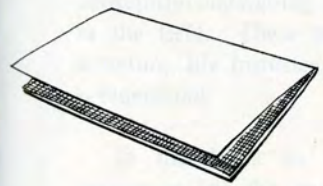


Fig. 10

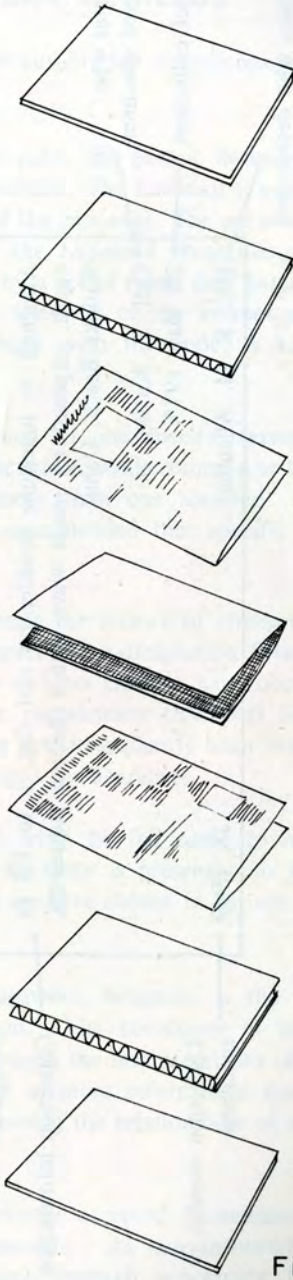
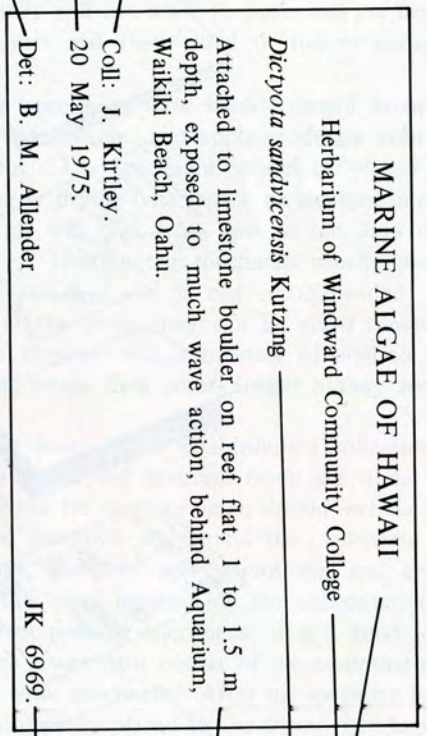


Fig II

Figure 12: COLLECTION LABELS



CHECKLIST OF HAWAIIAN SEAWEEDS

The scientific names and their respective authors for the common seaweeds of Hawaii are listed starting on page 111.

A scientific name is composed of two parts, the generic designation and a specific epithet, hence it is termed a *binomial.* The binomial is customarily followed by the name(s) of the author(s) of the binomial. The use of scientific binomials, composed of Latin, Greek, or the Latinized vernacular, and the designation of the author(s), are governed by a set of rules, the "International Code of Botancial Nomenclature." The selection of the correct scientific name and author designation, in conformity with the code, is known as nomenclature.

Scientific binomials can only be applied to one specific seaweed even though it may be distributed throughout the world, while common or Hawaiian names may be incorrectly applied to more than one seaweed. Generic names are always capitalized and it is recommended that specific epithets are written with a small letter.

The arrangement of author names reveals the history of changes (if any have occurred) in the binomial. For example, in the designation *Ulva fasciata* Delile, Delile gave the seaweed its name and no changes have occurred in the binomial; the desingation *Pterocladia caerulescens* (Kutzing) Santelices indicates that the name assigned by Kutzing has subsequently been determined to be inaccurate or incorrect and was changed by Santelices.

Author names are usually abbreviated, with the full name to be found in more technical floras and manuals. As there is presently no such nomenclatural listing for Hawaiian seaweeds we have chosen to list the author's full name.

Apart from the nomenclature of a seaweed, however, is the separate question of its taxonomy or classification. The taxonomy of seaweeds, constantly undergoing refinement, is based upon the interpretations of experts in the field. These interpretations change as more information (i.e., ultrastructure, life histories, biochemistry) concerning the relationships of seaweeds is elucidated.

In this book we have used the currently accepted nomenclature and taxonomy for the common Hawaiian seaweeds. As new information and interpretations are published (there is much research concerning Hawaiian

seaweeds currently in progress) the nomenclature and taxonomy of some Hawaiian seaweeds will undoubtedly change. These nomenclatural or taxonomic changes, however, must always be associated with specific seaweeds, and regardless of the name changes that occur, the seaweed will always retain the same form, shape, and coloration as displayed in the photographs in this book.

REFERENCES

Abbott, I. A., and G. H. Hollenberg. 1976. *Marine Algae of California.* Palo Alto: Standford University Press. 827 pp.

Abbott, I. A., and E. H. Williamson. 1974. *Limu. An Ethnobotanical Study of Some Edible Hawaiian Seaweeds.* 2nd edition. Lawai, Kauai: *The Bulletin.* Pacific Tropical Botanical Garden. 21 pp.

Bold, H. C. and M. J. Wynne. 1978. *Introduction to the Algae: Structure and Reproduction.* New Jersey: Prentice-Hall. 768 pp.

Dawes, C. J. 1974. *Marine Algae of the West Coast of Florida.* Miami: University of Miami Press. 201 pp.

Dawson, E. Y. 1966. *Marine Botany.* New York: Holt, Rinehart and Winston, Inc. 371 pp.

Dixon, P. S. 1973. *Biology of the Rhodophyta.* Edinburgh: Oliver and Boyd. 285 pp.

Dodge, J. D. 1973. *The Fine Structure of Algal Cells.* New York: Academic Press. 261 pp.

Doty, M. S. 1957. *List of Published Hawaiian Names for Seaweeds.* Manoa: Dept. of Botanical Sciences, University of Hawaii. 7 pp.

Fogg, G. E., W. D. P. Steward, P. Fay, and A. E. Walsby. 1973. *The Blue green Algae.* New York: Academic Press. 459 pp.

Fortner, H. J. 1979. *The Limu Eater: a Cookbook of Hawaiian Seaweeds.* Sea Grant Miscellaneous Reports UNIHI-Sea Grant-MR-79-01. 107 pp.

Fritsch, F. E. 1935 & 1945. *The Structure and Reproduction of the Algae.* Cambridge: University Press. I: 1 – 791; II: 1 – 939.

Hunt, J. W. 1978. Algal Biochemical Tricks and Classification. The American Biology Teacher 40 (9): 528-531.

Levring, T., H. A. Hoppe, and O. J. Schmidt. 1969. *Marine Algae: A Survey of Research and Utilization.* Hamburg: Cram, DeGruyter and Co. 421 pp.

Morris, I. 1968. *An Introduction to the Algae.* 2nd edition. London: Hutchinson University Library. 189 pp.

Pickett-Heaps, J. D. 1975. Green Algae. Structure, Reproduction, and Evolution in Selected Genera. Sunderland, Mass: Sinauer Associates, Inc., Publishers. 606 pp.

Round, F. E. 1973. *The Biology of the Algae.* 2nd edition. New York: St. Martin's Press. 278 pp.

Setchell, W. A. 1905. *Limu.* Univ. Calif. Publ. Bot. 2 (3): 91–113.

Stewart, W. D. P. (ed.). 1974. *Algal Physiology and Biochemistry.* Berkeley: University of California Press. 989 pp.

Taylor, W. R. 1960. *Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas.* Ann Arbor: The University of Michigan Press. 870 pp.

Tranor, F. R. 1978. *Introductory Phycology.* New York: Wiley. 525 pp.

APPROXIMATE CONVERSIONS FROM METRIC MEASURES

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
		VOLUME		
ml	milliliters	0.2	teaspoons	tsp
ml	milliliters	0.07	tablespoons	Tbsp
ml	milliliters	0.03	fluid ounces	fl oz
ml	milliliters	0.004	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal