



TECHNICAL REPORT

The University of the South Pacific

**GUIDE TO THE COMMON SEAWEEDS
OF
PALOLO DEEP MARINE RESERVE
APIA, SAMOA**

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&
G. Robin South**

**The University of the South Pacific
Marine Studies Programme
July 2000**



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PALOLO DEEP MARINE RESERVE, APIA,
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by

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photosynthetic plants, but this green chlorophyll pigment is masked by other pigments, giving them blue-green, brown and red colouration. Seaweeds are placed in different groups according to their colour, and at Palolo Deep the principle groups are:

Blue-green algae – Cyanophyceae
(phycocyanin pigments)

Green algae – Chlorophyceae
(chlorophyll pigments)

Brown algae – Phaeophyceae
(xanthophyll pigments)

Red algae – Rhodophyceae
(phycoerythrin pigments)

Only the green, brown and red seaweeds are considered in this Guide.

Seaweeds are simple but diverse plants; their body is called a **thallus**, and it may be very simple or, in more advanced forms may have a **holdfast** (attachment organ), a **stipe** (stem) and **blades** (leaf-like). The holdfast may be a single modified basal cell, or a strong structure capable of attaching the seaweed in places of strong wave action. The stipe and blade may not be present in all seaweeds, and in some forms the whole plant is a crust-like structure, firmly attached to the substratum. In others the blade may be very prominent and leaf-like (as in *Sargassum*), or it may be very fleshy and soft, taking on a variety of forms. A number of tropical seaweeds have walls that are lightly or heavily impregnated with calcium carbonate (chalk-like substance), which gives them a rock-like texture. The red crustose coralline algae are of this form and are very important in binding together the corals on the reef, while the green seaweed *Halimeda* is a very important contributor to the 'sand' that makes up the beach on many tropical shorelines.

Reproduction in seaweeds is of three kinds: **sexual**, **asexual** and **vegetative**. In sexual reproduction male and female gametes are formed in gametangia (the antheridium in the male, and the oogonium in the female). The gametes may be motile or non-motile, and after fertilisation, a zygote is formed. In the red algae, the zygote results in the

development of a structure called a cystocarp, which contains the **carposporophyte**. In asexual reproduction, motile or non-motile spores are produced, which can act as a rapid means of reproduction. In vegetative reproduction, plants may reproduce from fragments or special structures (such as propagules), without the intervention of sexual stages.

Many species of seaweeds exhibit a phenomenon known as **alternation of generations** in their life cycles. In the simplest, two stages known as the **gametophyte** and **sporophyte** occur, while in most red algae three stages are involved (gametophyte, tetrasporophyte and carposporophyte). If the phases (plants) look alike the life cycle is described as **isomorphic**, while if they are different, the life cycle is described as **heteromorphic**.

Seaweeds are limited in distribution to the region where light penetrates water sufficiently to allow for photosynthesis (referred to as the photic zone). In tropical regions the greatest depth where seaweeds are found is around 270 metres. At Palolo Deep seaweeds occur from above the high tide level (some blue-green algae) to depths yet to be determined, but probably more than 150 m depth on the outside of the reef. The depth of the deep (25 m) is well within the range at which seaweeds would occur.

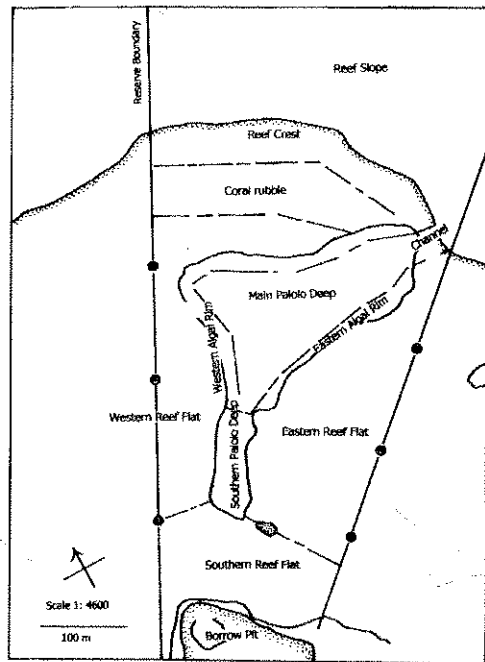
In many parts of the world seaweeds are of considerable economic importance, both as human food, and as sources of extracts of industrial value. Seaweeds are consumed in Samoa, and the commonest are the green seaweed *Caulerpa* (Limu fuafua) and the red seaweed *Halymenia* (Limu a`au, Limu mumu).

SEAWEED HABITATS

The seaweeds at Palolo Deep occur in a variety of different habitats. These are shown on the map of the Reserve. The greatest number of species occur along the margins of the deep and along the

reef front, while the smallest number occurs in the borrow pit.

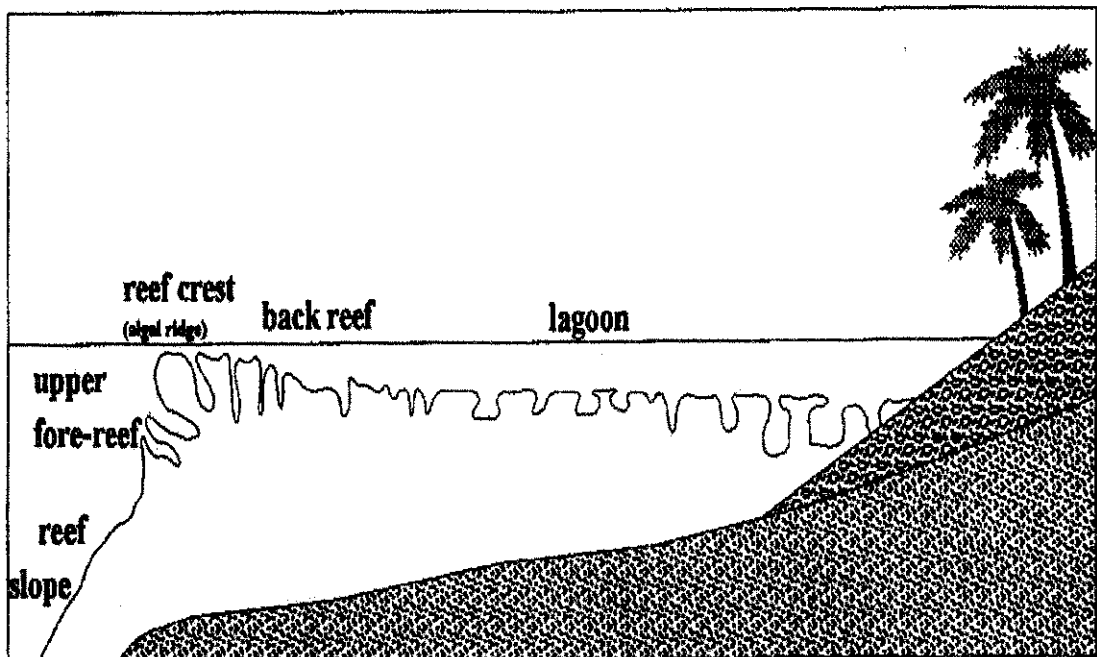
Refer to the generalised diagram of a reef ecosystem, to get your bearings as to the importance of the different habitats. Many factors in the environment greatly influence the nature of the habitats, such as the tides, the slope of the shore, the exposure to strong waves and currents, and the possible influence of freshwater. There are many fishes that feed on seaweeds, and this is one reason why in the tropics seaweeds often occur as a heavily grazed turf of small, crowded individuals. These turfs may be made up of quite a few species. Many of the small seaweeds may live on the thallus of larger species as epiphytes, or in their crowded holdfasts, so these are places that have to be carefully searched. On the reef itself, many seaweeds are found in crevices among the corals, where they seek protection from grazing animals. The most extreme method of hiding and avoiding grazers is exhibited by those microscopic seaweeds that live inside the tissues of other seaweeds, or in the shells of animals.



Map of Palolo Deep National Marine Reserve

Collection and preservation of seaweeds

The collection of seaweeds is not permitted at Palolo Deep, since it is a marine reserve. For scientific study,



Section of a typical fringing reef

however, seaweeds must be collected for laboratory examination, since most of the species are very small and cannot be identified in the field.

Seaweeds once collected are preserved in a solution of 4% formaldehyde (can be obtained from a Pharmacy) in seawater, and in the laboratory are prepared as pressed herbarium specimens, on microscope slides or in formaldehyde or alcohol liquid.

The main research collection of Palolo Deep marine algae is held in the South Pacific Regional Herbarium at the Marine Studies Centre, the University of the South Pacific in Suva, Fiji. This important reference collection is permanently preserved for future generations of students and researchers.

COMMON SEaweEDS OF PALOLO DEEP

RED ALGAE (RHODOPHYCEAE)

The red algae have chlorophyll like all other photosynthetic plants, but this is masked by a variety of other pigments, which may make the plants look red, violet, brown or even black in colour. The cell walls of some red algae contain valuable compounds including agar and carrageenan, widely used in the pharmaceutical and food manufacturing industries. At present, none of Samoa's red algae are used for their compounds, although one species *Halymenia* is favoured as a food delicacy by many Samoans.

Red algae are the most numerous of the tropical algae and range in form from very simple filaments, to large leafy blades approaching a metre in length; many red algae are heavily impregnated with calcium carbonate and may be branched or entirely prostrate.

The majority of the red algae are subtidal, although many are also found as turf-forming species, as epiphytes on other algae (such as *Sargassum* and *Halimeda*) or as larger species in the lagoon and on the reef flat. The encrusting coralline

species form a red 'paint' on the reef crest (known as the algal ridge) and are essential in binding together and consolidating the delicate latticework of the corals. They also assist in breaking the force of the waves on the reef front.

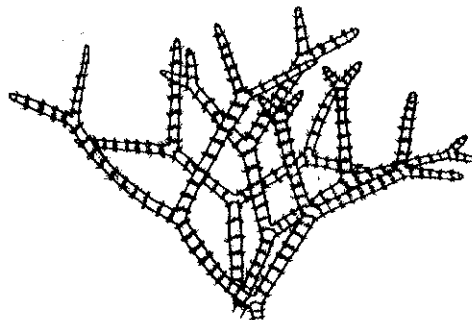
A total of 88 species of red algae have been found at Palolo Deep, and four of these are new to science. Here we describe 22 species, most of them common at the Deep and elsewhere in Samoa.

Family Galaxauraceae

ACTINOTRICHIA

Actinotrichia fragilis (Forsskål)
Børgesen

Plants form bright orange wiry clumps on rocky substrata and on the reef flat in shallow subtidal areas. The branches are repeatedly forked, less than a mm in diameter. The branches have a distinct banded appearance, the bands made up of whorls of filaments. It has been reported that extracts from this seaweed can reduce blood cholesterol levels.

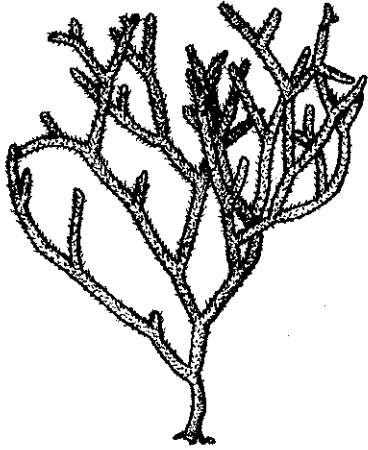


GALAXAURA

Galaxaura divaricata (Linnaeus)
Huisman & Townsend.

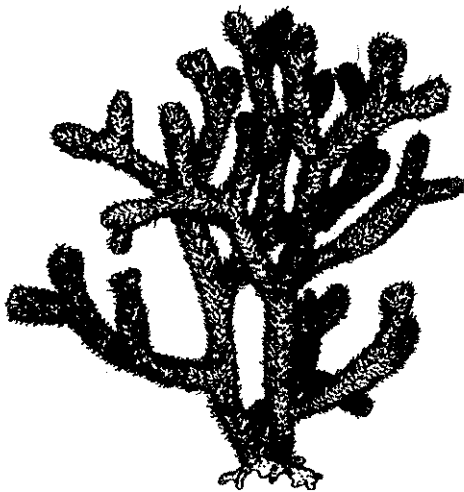
Plants wiry and hairy throughout, bushy, to 10 cm tall, attached by a distinctive holdfast up to 5 mm in diameter; branches dichotomous. May be confused with *Actinotrichia fragilis* but is distinctive by its wiry and hairy appearance, the hairs not forming 'rings' or whorls as in the former species. Generally of light purple red colour. Common along the algal rim of the Deep, to 10 m depth.

depth. This species is distinctive by its lack of 'hairy' filaments and flattened branches.



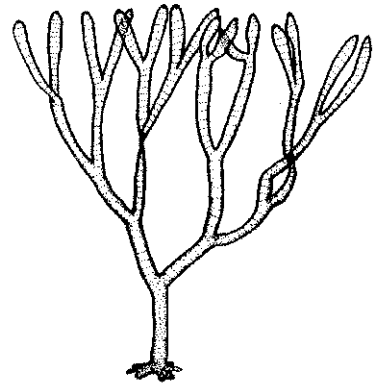
Galaxaura filamentosa Chou

The thallus is rigid, up to 8 cm tall, dark brown and densely branched, the branches covered in filaments. Common in the main Deep and along the algal rim of the Deep, from 5 – 20 m depths. Plants are often covered with silt and fine sand. This seaweed differs from the above by its more bushy appearance and its dark crimson colour.



Galaxaura marginata (Ellis & Solander)
Lamouroux

The thallus varies from greenish-white to red, flattened and smooth to leathery in texture, from 3-5 cm tall. The branching is dichotomous, the branches 1-2 mm broad. Uncommon, occurring along the algal rim of the Deep, and in the channel, to 10 m



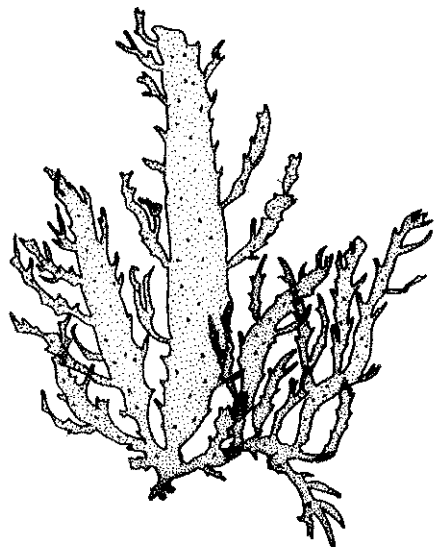
Family HALYMENIACEAE

HALYMENIA

Halymenia durvillei Bory de Saint-Vincent

(*Limu a'au*, *Limu mumu*)

The thallus is bladed, slimy in texture and dark red to light pink in colour, to 50 cm tall. Attachment is by a small holdfast; blades are beset with numerous strap-shaped branches up to 30 mm wide, and often terminate in tooth-like or acute tips. Mainly confined to the subtidal, although young plants may be found in the reef channel. A delicacy of the Samoans, who mix it with coconut cream and cook it in an *umu* (earth oven). Recent studies of bioactive compounds of this seaweed suggest that it might have anti-cancer properties.

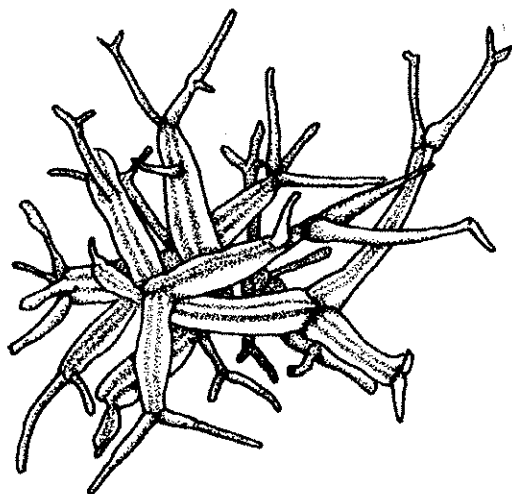


Family CORALLINACEAE

AMPHIROA

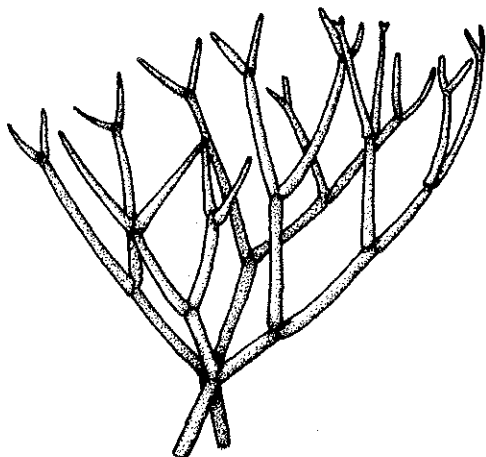
Amphiroa foliacea Lamouroux

Plants are decumbent, heavily calcified and pinkish-cream in colour, up to 3 cm tall. Branches normally dichotomous, distinctly articulated, the segments rounded to distinctly flattened. Fairly common on solid substrata and in strong wave action.



Amphiroa fragilissima (Linnaeus) Lamouroux

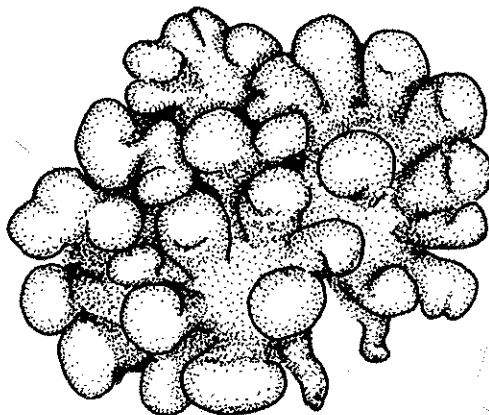
Plants pinkish, heavily calcified, forming delicate clumps up to 6 cm tall; branches rounded, not obviously articulated, dichotomous. This species is uncommon and is found along the algal rim of the Deep, to 10 m depth.



LITHOTHAMNION

Lithothamnion proliferum Foslie

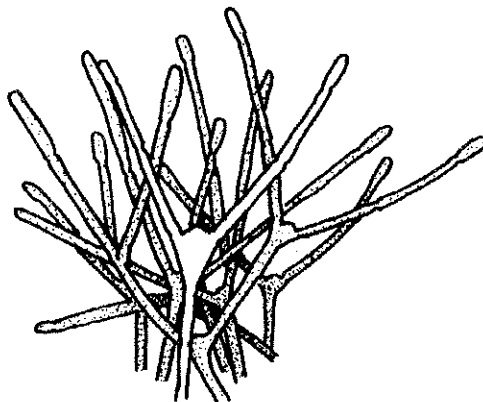
Plants are stony, crustose with numerous flattened, blunt uprights, glossy pink and smooth with a velvety texture. Occurs only in moderately to highly exposed places along the algal rim and on the reef front, favouring the undersides of overhangs, to 20m depth.



JANIA

Jania adhaerens Lamouroux

Plants calcified, forming a brittle, entangled mass up to 4 cm tall; branches terete, segmented, dichotomous, the branches diverging at more than 45 degrees angle. Fairly common from the shallow intertidal to the subtidal up to 10m depth. Many smaller algae inhabit the mass of *Jania*, probably thereby escaping from grazing fishes and invertebrates.

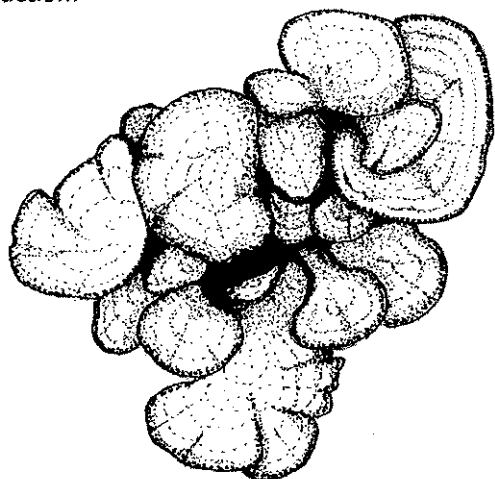


Family PEYSSONNELIACEAE

PEYSSONNELIA

Peyssonnelia inamoena Pilger

Thallus prostrate, made up of crispy, shiny, overlapping blades that are raised at the margins, light pink to rosy red in colour, showing faint radial to concentric lines, much paler below than above; attached on the underside by rhizoids. Grows on rock or coral, common in the lower intertidal to the upper subtidal especially in moderate to strong wave action.

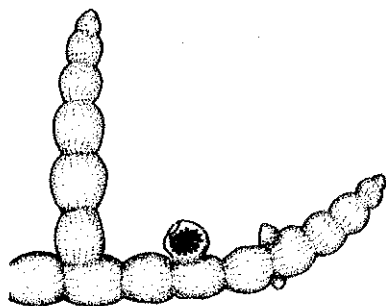


Family CHAMPIACEAE

CHAMPIA

Champia parvula (C. Agardh) Harvey

Plants form gelatinous, whitish-pinkish clumps, prostrate or erect to 3 cm tall, terete, the branches tapering towards the tips. Uprights are deeply segmented at regular intervals, due to deep constrictions. Occurs on larger algae (such as *Sargassum*) or attached to coral fragments or rocks, preferring areas of strong water movement.

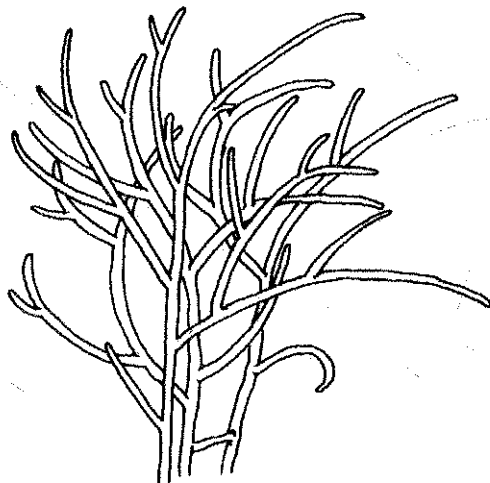


Family LOMENTARIACEAE

GELIDIOPSIS

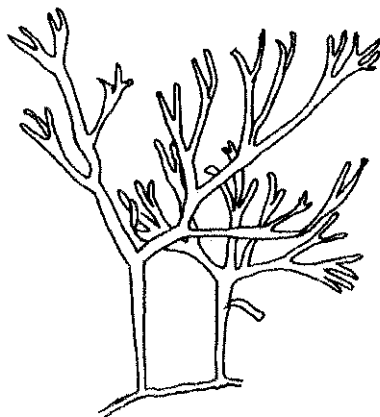
Gelidiopsis intricata (C. Agardh) Vickers

Plants occur as bushy, purplish-brown wiry clumps usually mixed with other seaweeds. The lower branches are somewhat creeping and entangled, while the erect branches are terete, strongly tapered and up to 5 cm tall. Common in places of moderate to strong wave action. This species is consumed in some countries, such as the Philippines.



Gelidiopsis scoparia (Montagne & Millardet) De Toni

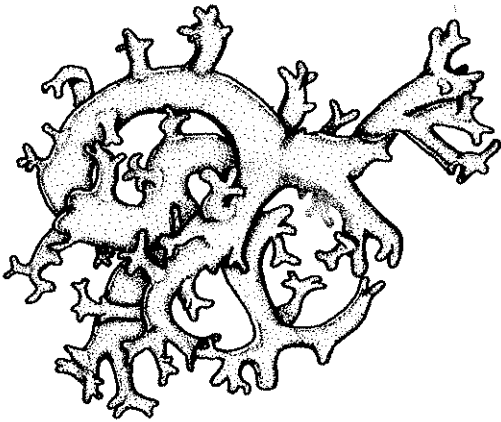
Plants are wiry, light green in colour, the uprights up to 4 cm tall. Branches are compressed and give rise to palmate fronds. Common in the upper subtidal, on rocks, coral rubble or epiphytic on other algae, especially *Galaxaura*. Often entangled with other turf algae.



ROSENINGEA

Rosenvingea intricata (J. Agardh)
Børgesen

Plants cushion-like, up to 10 cm in diameter, greenish brown or yellowish in colour, made up of hollow tubular branches, the branches divided at the ends, somewhat inflated. Uncommon, seasonal in the cooler months, preferring sheltered sites, attached to coral fragments and shells. Is taken as human food in SE Asia.



Sargassum polycystum C. Agardh

Plants may approach 1 m in length, attached by a small discoid holdfast. Stem strongly covered with warty Y-shaped spines, leaves ovate to narrowly spear-shaped; leaf margins smooth to irregularly toothed. Numerous air bladders (vesicles) at the base of the leaves, especially towards the tip of the plant. Reproductive

Family SARGASSACEAE

SARGASSUM

Sargassum cristaefolium C. Agardh

Plants up to 45 cm tall, attached by a discoid holdfast. Main axes slightly flattened and smooth, with many side branches; leaves in younger parts strap-shaped, up to 5 cm long, thickened in mature leaves, which are more spade-shaped; ends of leaves are "double" and strongly toothed. The reproductive structures are borne on densely crowded elongate structures arising from the axils of the branches. Occurs commonly in the intertidal from the reef flat to the back reef, able to resist very strong wave action. In SE Asia used as a fertiliser; other uses include human food, antibacterial and anti-tumour properties, prevention of fever in children, regulation of goitre and blood cholesterol levels.



branchlets dense, somewhat twisted, forked or simple, with teeth or spines at the margin and tip. This plant thrives in the inner reef areas on coarse, sandy-coraline substratum not exposed to strong wave action or water turbulence. This is the largest and most conspicuous alga from Palolo Deep. *Sargassum polycystum* has many uses in SE Asia, comparable to those for *S. cristaefolium*.

TURBINARIA

Turbinaria ornata (Turner) J. Agardh

Plants are erect, very tough dark brown, to 12 cm tall, attached to the rocky substratum by coarse, branched holdfasts. Leaves are thick, terminally expanded to form a circular blade that is outlined by sharp coarse teeth; the centre of the blade is concave and surrounded by a second crown of teeth. The uses of this seaweed in SE Asia are comparable to those reported for species of *Sargassum*.



GREEN ALGAE (CHLOROPHYCEAE)

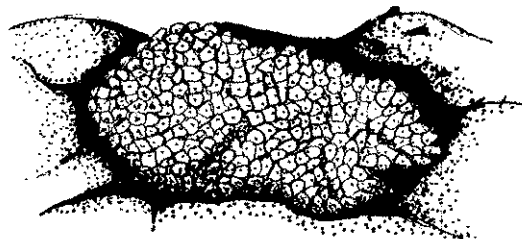
In green algae the predominance of chlorophyll pigments gives them their green colouration. A number of tropical genera have mild to strong calcification of the cell walls: calcified species may have a whitish colouration. The dead remains of calcified Chlorophyceae are important in the formation of beach sands in tropical regions. Sexual, asexual and vegetative reproduction all occur in this group. Sexual reproduction is frequently by motile gametes; and there are often two phases in the life cycle. Vegetative multiplication through fragmentation of the thallus is common. Green algae have many growth forms, ranging from simple filaments to complex plant bodies as found in *Halimeda*. Some tropical green algae are essentially one large cell: the most dramatic example of a single large cell is *Ventricaria ventricosa*, sometimes referred to as the sailor's eyeball. A total of 24 green algae have been reported from Palolo Deep, eleven of which are described here.

Family SIPHONOCLADACEAE

DICTYOSPHAERIA

Dictyosphaeria versluysii Weber-van Bosse

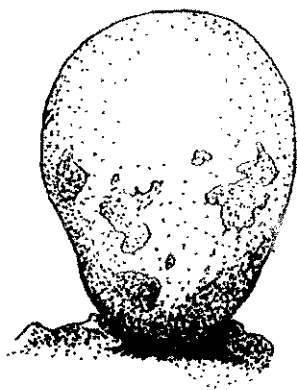
Plants a green to yellowish green forming globular, hard clumps up to 5 cm wide; the surface of the thallus appears prismatic or beaded; thalli firmly attached to one another and the substratum. Occur in very exposed locations from the back reef to the reef crest; usually closely embedded in the substratum and hard to remove.



VENTRICARIA

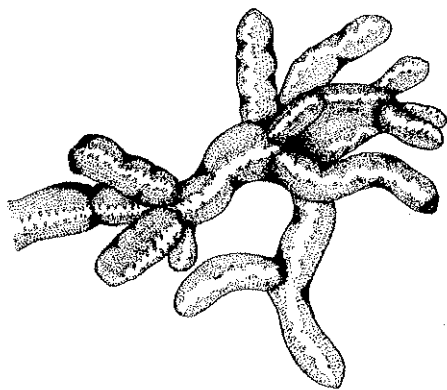
Ventricaria ventricosa (J. Agardh)
Olsen & West

Thallus a solitary water-filled globe, up to 6 cm in diameter; green to gray-green in colour, or heavily encrusted with pinkish coralline algae; attached to the substratum by many minute rhizoids at the base. Often partially hidden in crevices, at the bases of corals or rocks; common from the algal rim to subtidal areas.

**VALONIA**

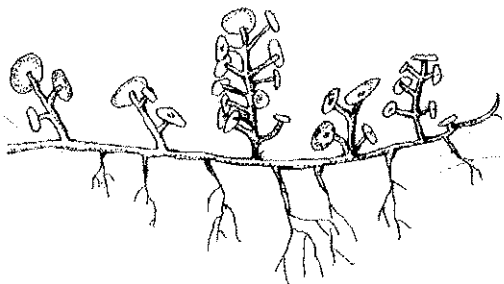
Valonia fastigiata Harvey ex J. Agardh

Thallus consists of shiny green vesicles up to 9 mm long, forming dense cushions up to 15 cm or more in diameter. Vesicles are variously branched, and often joined to one another. Common from the intertidal flat, the algal rim to the reef crest.

**Family CAULERPACEAE****CAULERPA**

Caulerpa peltata Lamouroux

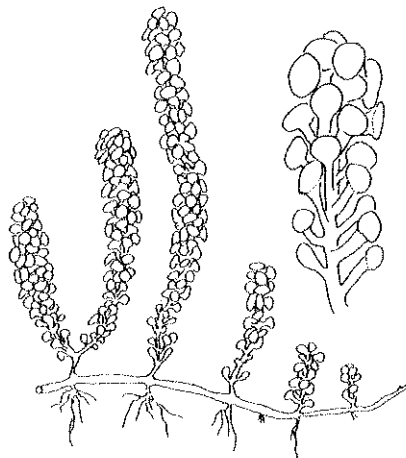
Plants are dark green, and consist of a creeping stolon attached by clusters of rhizoids at regular intervals; the stolon gives rise to upright branches to 5 cm tall; uprights branched, the branches terminating in a disk of variable diameter. Common from the algal rim to the reef crest, and subtidally to 25 m depth.



Caulerpa racemosa (Forsskål) J. Agardh

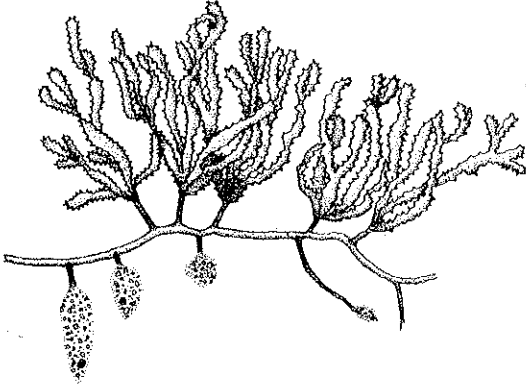
(*Limu fuafua*)

Plants are bright green, and consist of a creeping stolon attached by clusters of rhizoids, and giving rise to uprights up to 10 cm tall; uprights bear numerous small, spherical branchlets, grape-like in appearance. Uncommon on the reef flat and algal rim, but very abundant in the borrow pit, where it is the dominant alga. This plant is a favourite food of the Samoans, and is sold in the Apia market. It is also eaten by many other Pacific Islanders.

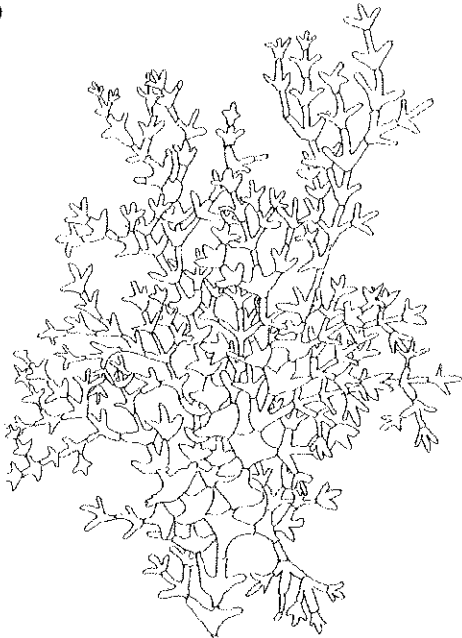


Caulerpa serrulata (Forsskål) J. Agardh

Plants are dull green, and grow in a similar manner to other species of *Caulerpa*. In this species, the uprights are irregularly to dichotomously branched and bear leafy, compressed, often strongly twisted and strongly toothed branchlets. Common at most sites in the Reserve, and occurring in the subtidal to 25 depth. Also occurs in the borrow pit, where the thallus takes on a somewhat different form.

**Family CODIACEAE****HALIMEDA*****Halimeda copiosa*** Goreau & Graham

Thallus whitish-green, arising from a single, inconspicuous holdfast; strongly calcified and composed of segmented axes and branches, the segments flattened and lobed; branching usually in one plane. Common in relatively calm areas, to 25 m deep

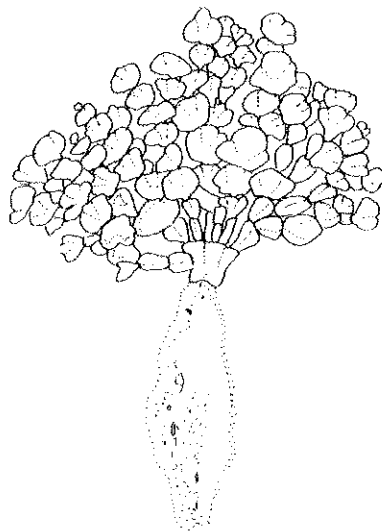
***Halimeda opuntia*** (Linnaeus)

Lamouroux

Thallus whitish-green, strongly calcified and composed of segmented axes and branches, the individual segments heavily ribbed; attached by an inconspicuous holdfast, usually obscured by many other attachment points where branches come into contact with each other and the substratum; branching irregular and in many planes, the plants growing as dense clumps up to 30 cm in diameter. Very common throughout the Reserve.

***Halimeda incrassata*** (Ellis) Lamouroux

Plants to 12 cm high, moderately calcified, often resembling a fan, attached by a distinct holdfast. Found only in the Deep at 25m depth, although it grows in sheltered shallow areas in other places.

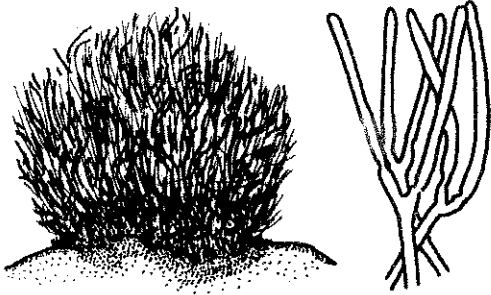


Family UDOTACEAE

CHLORODESMIS

Chlorodesmis fastigiata (C. Agardh)
Ducker

Thallus bushy, erect to 10 cm tall, very bright green and one of the most noticeable species on the reef crest or other strongly turbulent areas. Frequently referred to as turtle weed, when abundant this species is a useful indicator of organic pollution. Extracts of this alga have the unusual property of preventing cell division in sea urchin eggs.

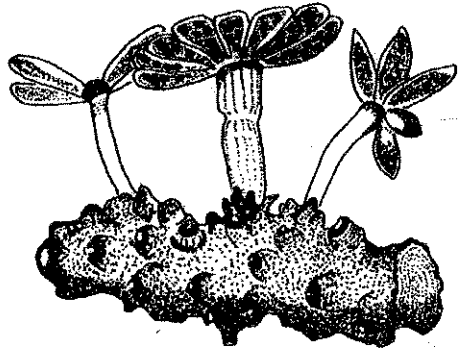


Family POLYPHYSAEAE

ACETABULARIA

Acetabularia parvula Solms-Laubach

Plants minute, umbrella-like with a delicate stalk and expanded cap of radial segments, up to 2.5 mm tall, chalky green in colour, calcified. Common throughout the Reserve, attached to coral rubble in sheltered, often shady sites including the underside of rocks.



GLOSSARY

agar – red algal polysaccharide of commercial value

alternation of generations – algal life cycle with an alternation between gamete producing and spore producing phases

antheridium – male sex organ producing antherozoids, or male gametes

articulated – upright branch system of coralline algae that have distinct nodes and internodes and are therefore able to bend

axis (axes) – main upright of a plant

blade – leaf-like, flattened part of an algal thallus

carpogonium – in red algae, the cell producing the female gamete (ovum or egg)

carposporophyte – spore-producing generation of red algae, producing carpospores

carrageenan – red algal polysaccharide used for commercial purposes

cartilaginous – rather coarse and stiff in texture, papery, not calcified

coralline algae – members of the red algae with their cell walls heavily impregnated with calcium carbonate

cystocarp – spore producing structure in red algae, developed after fertilisation and remaining attached to the female plant

decumbent – describes a mode of growth where the plant grows close to the surface of the substratum, with only limited uprights

dichotomous – mode of branching where branches divide equally to give rise to two branches of equal length

ecosystem – all of the habitats and species in an environment, and their interaction

epiphyte – seaweed that grows on another, usually larger seaweed

filament – upright thallus often composed of a single tier of cells; usually terete

gametangium (-ia) – cell or organ producing gametes

gamete – male and female sex cells, e.g. sperm (male) and egg (female)

gametophyte – gamete producing phase

heteromorphic – the kind of alternation of generations where the gamete and spore producing phases are dissimilar

holdfast – attachment organ of an alga

intertidal – between low and high tide levels

isomorphic – the kind of alternation of generations where gamete and spore producing phases look alike

midrib – thickened vein running down the centre of a blade (as in a leaf on a flowering plant)

oogonium – female sex organ producing ova (or eggs) – female gametes

palmate – describes a hand-shaped mode of growth

photic zone – the zone below the surface of the sea where sufficient light penetrates to allow photosynthesis by marine algae (usually 150 – 250 m depth in the tropics)

propagule – vegetative reproductive structure capable of developing into a new plant

prostrate – same as decumbent

rhizoid – attaching organ, of a single cell or otherwise simple compared with a holdfast

seaweed – a simple plant, or alga, found in the sea

serrated – toothed

sexual – mode of reproduction involving male and female reproductive organs, or gametes

spermatangium in red algae, the cell producing the male gamete (or spermatium)

sporophyte – spore producing phase

stipe – stem of an alga

stolon – running root-like structure

subdichotomous – mode of branching where branches divide but not quite dichotomously, the branches somewhat uneven in length

subtidal – below the level of the lowest tides

terete – round in cross-section

thallus – the plant body of an alga

vesicle – sac-like structure, hollow in the centre and possibly filled with liquid

zygote – cell resulting from fusion of male and female gametes

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