

# **Seaweeds** - A field Manual

# Seaweeds - a field manual

© National Institute of Oceanography, Dona Paula, Goa. 403 004

*Disclaimer* : The authors are responsible for the contents of this manual

First Edition : March 2004

V.K. Dhargalkar  
Devanand Kavlekar  
National Institute of Oceanography  
Dona Paula, Goa - 403 004

## *Editors*

X.N. Verlecar  
Vijaykumar Rathod  
National Institute of Oceanography,  
Dona Paula, Goa - 403 004

## *DTP*

Devanand Kavlekar  
Bioinformatics Centre,  
National Institute of Oceanography, Dona Paula, Goa

## *Financial Support*

Ministry of Environment & Forests, New Delhi

## FOREWORD

Since its inception in 1966 the National Institute of Oceanography is involved in taxonomic classification of marine phytoplankton, zooplankton, benthos and other flora and fauna under the Project “ Measurement and Mapping of Marine Resources”. Although the mandate of the project has been diversified with changing times, the taxonomic identification continues to remain the thrust area for all biological projects, especially those dealing with baseline studies on ecobiology and environmental pollution. Visiting post-graduate and post-doctorate students constantly look for information on taxonomic identification which is spread over several books and journals.

The project “Survey and Inventerisation of Coastal Biodiversity (West coast) funded by Ministry of Environment and Forests (MoEF), New Delhi, provided an opportunity to bring together taxonomic experts from various disciplines. Their efforts have resulted in preparation of this manual. This manual provides details of taxonomic classification and description of the concerned organisms /species. All the figures are well illustrated and detailed identification key is provided. This should surely guide even a beginner to understand the identification procedure.



S.R.Shetye

Director. NIO

## PREFACE

Seaweeds ! are not mere weeds but are valued marine plants. The multifacet uses of these plants in food, chemical and textile industries, agriculture, pharmaceuticals and medicine have been well recognized.

Our Indian coast including two groups of islands, harbour around 800 seaweed species belonging to Chlorophyta, Phaeophyta, and Rhodhophyta. This vast and economically important ocean resource required to be conserved, protected and utilized on sustainable bases. This is possible by following proper scientific standerized sampling procedure, correct species identification, inventorization and documentation as well as quantitative assessment to evaluate standing stock and standing crop of the economically valuable species. Often seaweed information is scattered in books, journals, reports etc. and are not readily available to the larger research community.

This manual presents sampling procedure, processing of the samples, wet and dry preservations and qualitative and quantitative assessment of seaweed resources. Keys to common genera and species are given as an examples for the identification. For further identification upto species level books may be refered.

We are sure that this manual will be very handy and useful to the ammatuers, students, researchers and scientists in seaweed study. We take the responsibility of any inadvertent errors in this manual.

V.K. Dhargalkar  
Devanand Kavlekar

## CONTENTS

1. Introduction
2. Green algae (Chlorophyta)
  - 2.1 Morphology
  - 2.2 Anatomy
  - 2.3 Pigments
  - 2.4 Reproduction
3. Brown algae (Phaeophyta)
  - 3.1 Morphology
  - 3.2 Anatomy
  - 3.3 Pigments
  - 3.4 Reproduction
4. Red algae (Rhodophyta)
  - 4.1 Morphology
  - 4.2 Anatomy
  - 4.3 Pigments
  - 4.4 Reproduction
5. Intertidal seaweed collection procedure
  - 5.1 Line transect or belt transect method
  - 5.2 Random sampling method
6. Subtidal seaweed collection procedure
  - 6.1 Line transect or belt transect method
  - 6.2 Random sampling method
7. Sample preservation
  - 7.1 Wet preservation
  - 7.2 Dry preservation
8. Procedure for preparing herbarium
9. Identification of seaweed species
10. Quantitative assessment of abundance
11. Field data sheet
12. Labeling

13. Key to common genera of chlorophyta
    - 13.1 Key to species
  14. Key to common genera of Phaeophyta
    - 14.1 Key to species
  15. Key to common genera of Rhodophyta
    - 15.1 Key to species
  16. References
- Appendix – I & II
- Plates

## 1. Introduction

Seaweeds or benthic marine algae are the group of plants that live either in marine or brackish water environment. Like the land plants, seaweeds contain photosynthetic pigments and with the help of sunlight and nutrient present in the seawater, they photosynthesize and produce food.

Seaweeds are found in the coastal region between high tide to low tide and in the sub-tidal region up to a depth where 0.01 % photosynthetic light is available (Fig. 1). Plant pigments, light, exposure, depth, temperature, tides and the shore characteristic combine to create different environment that determine the distribution and variety among seaweeds.

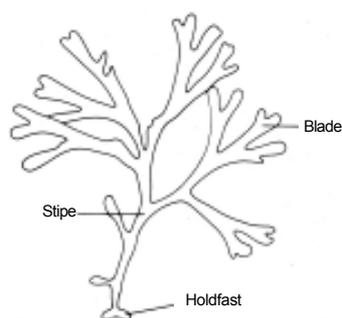
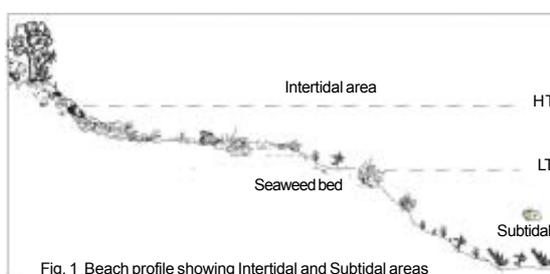
The important criteria used to distinguish the different algal groups based on the recent biochemical, physiological and electron microscopic studies are :

- photosynthetic pigments,
- storage food products,
- cell wall component,
- fine structure of the cell and
- flagella.

Accordingly, algae are classified into three main groups i.e. green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta).

Seaweeds are similar in form with the higher vascular plants but the structure and function of the parts significantly differ from the higher plants. Seaweeds do not have true roots, stem or leaves and whole body of the plant is called thallus that consists of the holdfast, stipe and blade (Fig. 2).

The holdfast resembles the root of the higher plants but its function is for attachment and not for nutrient absorption. The hold fast may be discoidal, rhizoidal, bulbous or branched depending on the substratum it attaches. The stipe resembles the stem of the higher plants but its main function is for support of the blade for photosynthesis and for ab



sorption of nutrients from surrounding sea water. The blade may resemble leaves of the higher plants and have variable forms (smooth, perforated, segmented, dented, etc.). The important functions of the blade are photosynthesis, absorption of nutrient. The most significant difference of seaweeds from the higher plants is that their sex organs and sporangia are usually one celled or if multi-cellular, their gametes and spores are not enclosed within a wall formed by a layer of sterile or non reproductive cells.

## **2. Green algae (Chlorophyta)**

### **2.1 Morphology**

Green algae are found in the fresh and marine habitats. They range from unicellular to multi-cellular, microscopic to macroscopic forms. Their thalli vary from free filaments to definitely shaped forms. The photosynthetic portion of the thalli may be moderately to highly calcified appearing in variety of forms as fan shaped segments, feather like or star-shaped branches with teeth or pinnules and clavate or globose branchlets.

### **2.2 Anatomy**

The cell has thick and stratified cell wall consisting of an inner cellulose and outer pectin layer. The pectin layer is impregnated with calcium carbonate in all Dasycladales and in many Siphonales. The majority of the chlorophyceae have uninucleate cell and multinucleate condition occurs in Cladophorales and Siphonales during the formation of reproductive units. In some cases, cell division occurs in plane parallel to the surface and result in a distromatic or pleurostromatic paranchymatous thallus. Protoplast usually possesses a conspicuous central vacuole often traversed by cytoplasmic strands.

### **2.3 Pigments**

Green algae possess photosynthetic pigments such as Chlorophyll *a* & *b*, contained in the special cell structure known as chromatophores. The chloroplast are found in varying shapes and sizes. It has double membrane envelope and no chloroplast endoplasmic reticulum is present. In many forms pyrenoids are present in the chloroplast, which are the major sites of starch formation. The pyrenoids

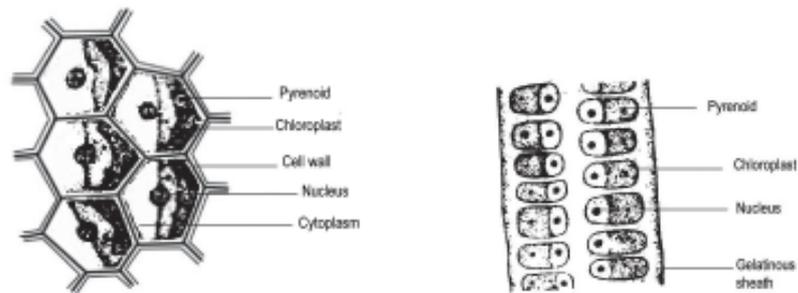


Fig. 3

of green algae are variably regarded as masses of reserve protein and as special organelles of the cell (Fig.3). The photosynthetic product of this group is starch.

## 2.4 Reproduction

Reproduction in Chlorophyceae shows great diversity. Green algae can produce sexually and asexually by forming flagellate and sometimes non-flagellate spores. The vegetative propagation is achieved through fragmentation.

Sexual reproduction may be by isogamous, anisogamous or oogamous type. The simple mode of reproduction is by isogamy i.e fusion of similar gametes. In anisogamy, both the gametes are flagellated but of different size, while in oogamy the male gamete is flagellated and fuses with large non-motile female gamete to form zygote. A large number of Chlorophyceae are haploid and reduction occurs in the germinating zygote. All the oogamous type shows similar life cycles. Homologous alternation of two identical phases is known to occur in number of Ulvalaceae and Cladophoraceae, while all of Siphonales appear to be deployed.

Asexual reproduction by zoospores (motile) or aplanospores (non-motile) produced by vegetative cells. In

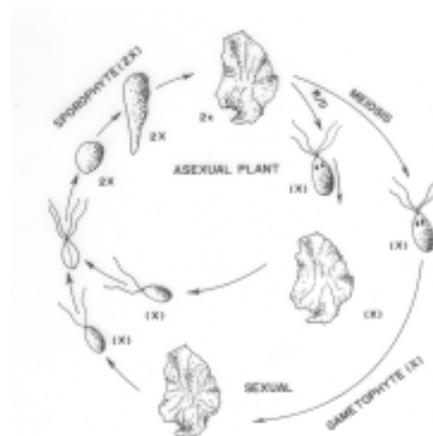


Fig. 4 Life cycle of *Ulva* sp.

many cases, the cells producing zoospores are not differentiated from vegetative cells and specialized sporangia are rare. The zoospores are formed either singly or in some numbers from the cells. The zoospores are naked and possess a more or less marked colourless beak at the anterior end from which flagella (two or four) arise. Aplanospores occur in both forms normally producing zoospores and as permanent development in many genera derived from zoosporic ancestor. Alternation of gametophytic and sporophytic generation occurs in this group (Fig. 4).

### 3. Brown algae (Phaeophyta)

#### 3.1 Morphology

Brown algae are exclusively marine forms. They have different forms from simple, freely branched filaments to highly

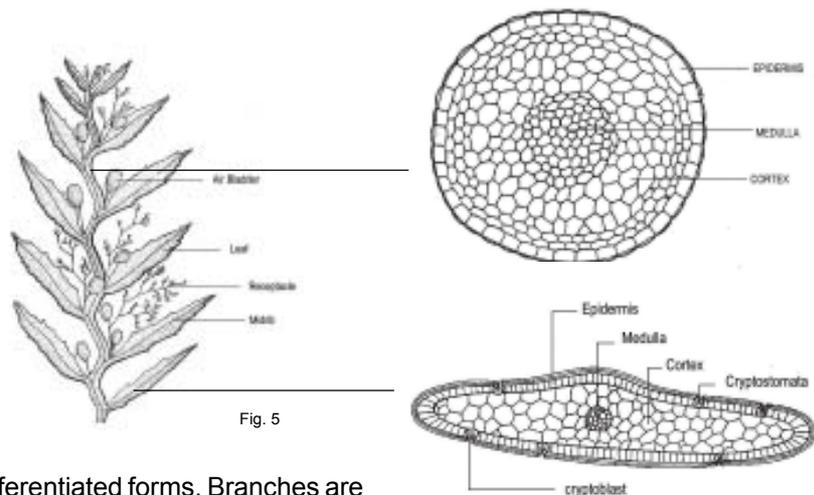


Fig. 5

differentiated forms. Branches are erect arising from prostrate basal filaments held together by mucilage forming a compact pseudo-parenchymatous aggregation of filaments into prostrate crust or erect branched axis or leaf like blades exhibiting the haplostrichous condition. Many species have large massive thalli with special air bladder, vesicles or float to make them buoyant (Fig. 5).

### 3.2 Anatomy

The cell wall is two layered. Outer layer is mucilaginous and sticky due to the presence of alginate. The inner layer is of cellulose (microfibrils). The cell is uninucleate with one or two nucleoli. The nuclei of Phaeophyta are usually large and possess a large and readily stained nucleolus with a delicate network having little chromatic material. The chromosomal organization is much advanced. The chromo centers on the chromosome of unknown function are characteristic of Phaeophyta. Cytoplasm contains organelles like mitochondria, golgi bodies, ER, chromatophores, vacuoles and fucosan vesicles. The chromatophores are invariably parietal. The photosynthetic cells in the majority of brown algae contain numerous small discoid chromatophores. Chromatophores show movement to changes in the intensity and direction of illumination.

### 3.3 Pigments

Brown algae vary in colouration from olive –yellow to deep brown. The colouration is due to the accessory carotenoid pigment and fucoxanthin. The amount of fucoxanthin varies in different species of brown algae. Dictyota, Ectocarpus, Laminaria etc. are rich in fucoxanthin, while species of Fucus are poor in fucoxanthin. Most of the littoral brown algae are rich in xanthophylls and fucoxanthin. The algae rich in fucoxanthin exhibit a much higher rate of photosynthesis in blue light than the algae with poor fucoxanthin.

The other photosynthetic pigments of the brown algae are Chlorophyll *a* & *c*, B-carotene and xanthophylls. The photosynthetic products of the brown algae are Laminarian and Manitol. Laminarian is dextrin like polysaccharide, a food reserve, arise from the simple sugar of photosynthesis. Manitol appears to be non widely distributed and presence of such alcohols may account for extreme scarcity of free sugars as they undergo immediate conversion into alcohol and polysaccharides.

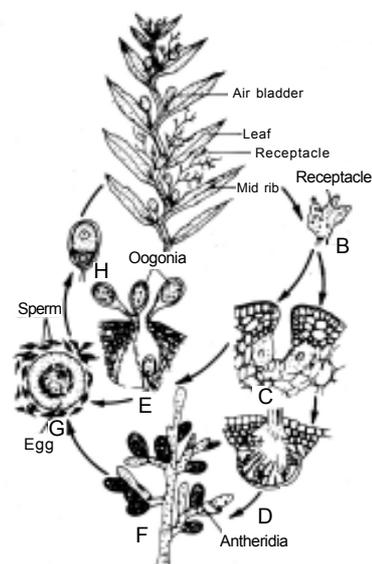


Fig. 6 Life cycle of *Sargassum* sp.

### 3.4 Reproduction

This group reproduces sexually and asexually. Several species of this group reproduce vegetatively by fragmentation. Members of this group produce biflagellate neutral spores found within one celled or many celled reproductive organs.

The asexual reproduction is by the formation of zoospores in the unilocular or pleurilocular sporangia except in Dictyotales, Tilopteridales and Fucales. Unilocular sporangia produce haploid gametophytic stage, while, pleurilocular sporangia produce diploid phase. The zoospores are asymmetric or bean shaped with two lateral or sub apical flagella. Zoospores are formed in the single celled unilocular sporangia by meiosis and give rise to gametophytes.

Sexual reproduction is by isogamy, anisogamy and oogamy. In oogamous type of reproduction, the male sex organ (antheridium) and the female sex organ (oogonium) may be produced on the same plant or on different plants (Fig. 6). Alternation of gametophytic and sporophytic generations occurs in this group except in the members of Fucales.



Fig. 7

## 4. Red algae (Rhodophyta)

### 4.1 Morphology

Except for few species they are exclusively marine. They vary in size and shape. They are either epiphytes, grow as crust on the rocks or shells as a large fleshy, branched or blade like thalli (Fig 7). The thallus is basically filamentous, simple or branched, free or compacted to form pseudoparenchyma with uni or multi-axial construction. They inhabit intertidal to subtidal to deeper waters.

### 4.3 Anatomy

Cells are eukaryotic. Inner cell wall is of cellulose and outer cell wall with amorphous matrix of mucopolysaccharides (i.e agar, porphyron, furcellaran, carrageenan). Cells are uninucleate/multinucleate with a large centric vacuole. The cross wall separating neighbouring cells exhibit a distinct feature - the pit

connection or pit plug. The cytoplasm exhibits a high degree of viscosity and there is often a very firm adhesion to the wall which penetrates to the inner most layer of the membrane. The cells of Rhodophyta are always uninucleate except in the older cells that are multinucleate. The nuclei exhibit a prominent nucleolus and a well developed network with numerous chromatin grains. The chloroplast varies from single, axial, stellate in primitive taxa to parietal and discoid forms in non advance taxa.

### 4.3 Pigments

The colouration of Rhodophyta is due to water-soluble pigments, the red phycoerythrin and blue phycocyanin. Other pigments present are chlorophyll *a* & *b*, carotene etc. The photosynthetic product of this group is Floridian starch. Phycoerythrin pigment is found to be in the greater quantity in seaweeds of deeper water and freely illuminated forms which also show increase ratio of phycoerythrin to chlorophyll. The accessory pigments that resemble those found in Myxophyceae are of proteins and show characteristic similar to those of globulin. Red algae carry on apparently more photosynthesis in feeble light than brown and green algae.

### 4.4 Reproduction

This group seldom reproduces asexually. All the members of this group produce one or more kinds of non-flagellated spores that are either sexual or asexual in nature.

Sexual reproduction is very complicated involving several structures after fusion of gametes. The male structure called antheridium produces a single spermatangia which give

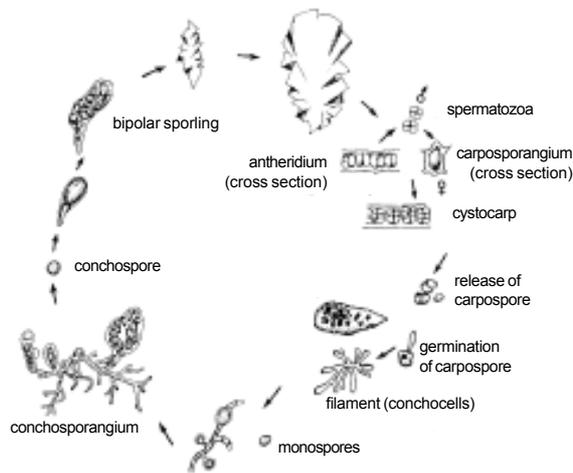


Fig. 8 Life cycle of *Porphyra* sp.

rise to non-motile spermatia. The female structure is a swollen carpogonium, which usually bears a long drawn out receptive trichogyne. The zygote is formed either by direct division as in Bangiales or after production of filamentous outgrowth called gonimoblast which give rise to number of sporangia each forming naked spore. Reduction occurs either at the first division of the zygote nucleus or is postponed and takes place in special tetrasporangia borne on individual distinct forms.

Some members of this group exhibit biphasic alternation of generation in which sexual generation (gametophyte) alternates with asexual (tetrasporophyte) generation, while others are triphasic with three generation or somatic phases (gametophyte, carposporophyte, tetrasporophyte) successively following one another (Fig. 8).

## **5. Intertidal seaweed collection procedure**

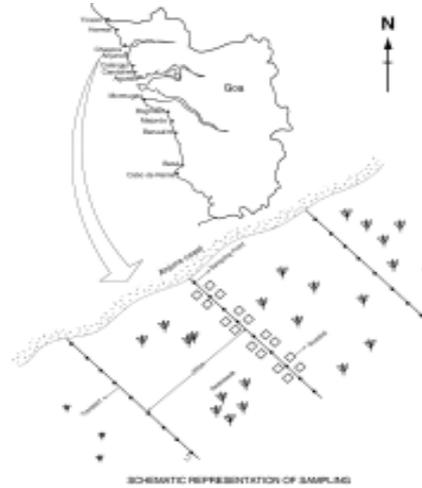
The collection of seaweeds from the intertidal area is done during the low tide. It is necessary to go for collection one or two hours before the time of low tide as per tide tables. This will give more time for seaweed collection and to observe seaweeds in the natural habitat. It is important to make notes on the description of the site location, topography, associated flora and fauna and other related parameters. Although, there are number of methods for qualitative and quantitative assessment of seaweeds, we consider here two methods which are practical and easy to study.

Material necessary for seaweed collection

- Polyethylene bags
- Knife or scalpel
- Labeling materials (pen/pencil, labels, marker pens etc.)
- Rubber bands
- Field note book
- Long rope (about 50 m long)
- Quadrant  $0.25 \text{ m}^2 / 1 \text{ m}^2$
- Mono pan balance

## 5.1 Line transect or belt transect method

To prepare a quantitative assessment of the marine vegetation in a given area, a line or belt transect is laid perpendicular to the coast from high tide to the low tide with the help of long rope (Fig. 9). Sampling points along the rope can be marked depending on the gradient and the expanse of the intertidal area. In case the intertidal area is small, sampling points can be marked at 5 m intervals along the rope and if intertidal area is quite large the sampling point can be marked at 10 or 20 m along the rope.



- A quadrant measuring  $0.25 \text{ m}^2$  area is placed at the sampling points in triplicate covering an area of  $5 \text{ m}^2$  on either side of the sampling points.
- Seaweed species present within the quadrant are collected (collect complete plant as far as possible along with the hold fast).
- Seaweed specimen can be removed by hand but those specimen which are closely adhering to the substrate such as crustose and mat forming seaweeds can be removed with the help of knife or scalpel. The specimen that grow close to the rocks can be removed with the rocks using geologist's pick axe or any other similar tools.
- All the collected specimen should be counted species wise and number of individuals in each species should be noted for quantitative assessment of abundance, density, frequency, species richness, species diversity, percentage cover etc. with statistical consideration.
- All the collected specimen from the quadrant should be weighed to estimate standing crop biomass.
- Collected material should be kept in the polyethylene bags/containers with proper labeling for further preservation and identification at the later stage in the laboratory.

## 5.2 Random sampling method

Samples can be selected at random as per requirement. This can be done by selecting sampling points in the area and using quadrant. Sampling points should be selected in such a manner that every species of the study area has good chance being selected. This type of sampling is usually done in the area where the intertidal expanse is very narrow with steep gradient and also in the area where distribution is patchy. It is also employed for qualitative estimation of the seaweed.

## **6 . Subtidal seaweed collection procedure:**

For subtidal area similar methods as in the case of intertidal area i.e. random sampling and belt/ line transect methods are used.

### **6.1 Line transect or belt transect method**

A transect perpendicular to coast is marked with the help of rope. The rope is fixed with nails and marked at regular interval at 5 to 10 m depending on the topography of the area.

The snorkeling technique is employed to sample shallow depth (0.5 to 3m) and SCUBA diving is employed in case of deeper depth (3.0 to 30m deep). The seaweed collection is done along the transect at 5 to 10m interval depending on the topography of the area. A quadrant of 1.0 m<sup>2</sup> area is used for collecting seaweed samples at the marked points. A canoe or boat or catamaran is used for fixing the sampling points and rope. Collected samples are analysed and processed as mentioned above.

### **6.2 Random sampling method**

Samples can be selected at random from the subtidal area of 0.5 to 3 m with snorkeling or SCUBA diving in deeper depths. A quadrant of 1 m<sup>2</sup> area is placed in the sampling area and seaweeds present in the quadrant are collected in polyethylene bags and similar procedure is followed as that of intertidal sampling.

## **7. Sample preservation**

### **7.1 Wet preservation.**

- All the adhering materials such as sand particles and other debris as well as epiphytes should be removed from the seaweeds before preservation.
- A solution of 5 -10 % formaldehyde in seawater should be prepared to preserve the seaweed sample.
- Before adding the preservative, water from the polyethylene bags / containers should be drained and sufficient preservative should be added. Fumes of the formaldehyde would help to fix and preserve the seaweed material. Polyethylene bags should be tied with rubber bands properly to prevent leakage

during transportation.

- All the bags / containers should be properly labeled with date of collection, locality and time and transport to the laboratory for further identification.

## 7.2 Dry preservation (herbarium)

Material required for preparing herbarium is as follows:

- Plastic trays
- Forceps
- Specimen mounting paper (herbarium sheets)
- Cheese cloth
- Blotting paper
- Herbarium wooden press
- Painting brush
- Pencils, knife etc.
- Polyethylene bags.



## 8. Procedure for preparing herbarium

- Fresh specimen should be cleaned of sand particles, rocks, shells, mud and other adhering materials and epiphytes.
- A tray containing fresh water (half filled) should be taken and specimen to be mounted be placed in the water.
- A herbarium sheet, size smaller than the tray to be inserted from below the specimen and then spread the specimen on the herbarium sheet with the help of brush in such a way that overlapping of the specimen is minimized.
- After mounting the specimen on the herbarium sheet, sheet is lifted slowly and tilted to one side to allow water to drain gradually without disturbing the

mounted specimen.

- Remove the sheet and properly arrange the specimen with the help of forceps or needle if required (Fig. 10).
- To blot dry, herbarium sheets are placed on the newspaper sheets or blotting paper to remove the remaining water from the herbarium.
- A cheese cloth is placed on the top of the specimen in such a way that it covers entire specimen.
- Now place another sheet of the blotting paper over the herbarium sheet.
- Once, all the specimen to be mounted are ready, herbaria are piled one above the other and then placed between the two sheets of the wooden press. The press is tied tightly with appropriate pressure by a rope.
- The press is kept at room temperature for 24 hrs. After 24 hours, blotting papers are required to be replaced. The process of replacing blotting papers is repeated till the time specimen is free of moisture.
- On drying of the specimen, the specimen get attached to the paper due to the phycocolloid present in the seaweed.
- The cheese cloth is carefully removed and herbarium sheet is properly labeled containing collection number, name of the specimen, locality, date of collection and other ecological details.
- Sometimes, specimen are thick and do not stick to herbarium sheets. In such cases gum or glue may be used to stick the specimen or specimen may be tied with thread.
- Prepare three to four more sheets of each specimen. One for yourself, one to send away for identification, one to file in museum and also for distribution and for exchange. Sheets can be placed in the polyethylene bags and sealed and stored.

## **9. Identification of seaweed species**

Although, identification of the seaweed species is difficult, time consuming, tedious; it is interesting, challenging, frustrating and humbling experience. The identification is often not only based on simple morphological criteria but also on reproductive structures, type of life history, cross sectional anatomical details,

type of growth, cytology and ultrastructural criteria and increasingly molecular evidence. Beginners should get familiar, first with herbarium specimen from the museum or reference collection before going for the field collection. Colour and morphological differences between different genera/ species and taxonomic characteristic are required to be carefully studied. Only thorough practice of handling and distinguishing the plants in the natural habitat will help a great deal in learning seaweed identification.

Taxonomic identification key should be followed to identify the seaweed specimen. The taxonomic description of the specimen and anatomical characteristic of the specimen to be identified should be referred from the books, monograph, reference herbaria etc. Once you identify the specimen tentatively following the key, you should compare it with the herbarium from reference center. Some of the seaweed species, particularly, filamentous are difficult to identify. In such cases chemo taxonomy or genetic approach could be employed. Later, you may once again get it confirmed from the experts in the field.

List of the other institutes where seaweed species can be identified are as follows.

- Botany Department, University of Pune, 411 007, Pune
- Regional Center of CMFRI, Madapan Camp, 623 520, Tamil Nadu.
- Central Salt Marine Chemical Research Institute, Bhavnagar, 364 002, Gujarat.
- Krishnamurthy Institute of Algology, 9 Lady Madhavan, 1st Cross Streets, Mahalinga puram, Chennai 600 034.
- Dept. of Botany, Andra University, Vizag, 530 003, Andhra Pradesh.

## **10. Quantitative assessment of abundance.**

To involve more realistic picture of the structure and dynamics of seaweeds one should resort to statistical consideration.

### **Density**

It is the count of the number of individual of the species and the total area sampled.

$D = n/A$  where  $D$  = density,  
 $n$  = total number of individuals of the species  
 $A$  = total area sampled.

### Frequency

It is the number of samples in which species occur and total number of samples taken.

$$F = j/k$$

where  $F =$  frequency  
 $j$  = number of samples in which species occur  
 $k$  = total number of samples

### Cover

This is the proportion of the ground or the substratum occupied by the individuals of the species.

$$C = \frac{a}{A}$$

where  $C$  = cover  
 $a$  = total area covered by species  
 $A$  = total area sampled.

### Species diversity

It is a measure of the number of species and the relative abundance of the individual of each species.

The commonly used methods for species diversity are the Simpson's Diversity Index and Shannon - Weiner Index

#### Simpson's Diversity Index

$$D = 1 - \sum (P_i)^2$$

### Shannon - Weiner Index

$$H = -\sum (P_i) (\log_2 P_i)$$

Where	D	=	Simpson's Diversity index
H	=		Shannon - Weiner Index of species Diversity
i	=		i <sup>th</sup> species.
P <sub>i</sub>	=		Proportion of i <sup>th</sup> species calculated as :total no. of individuals of species 'i' / total no. individuals of all the species.
S	=		No. of species

### Standing Crop Biomass

It is the weight of existing species in the given area at any one time.

$$B = (D) (TW/n)$$

where	B	=	biomass
	D	=	density
TW	=		sum of the weights of individual species in a sample.
n	=		number of individuals in the sample

### 11. Field data sheet

It is important to maintain accurate records of the field sample collection. All information should be recorded in the field data sheet. The field data sheet must include the date, time and locality of sample collection. Data sheet should also include other important information pertaining to the ecological parameters. Field notes should be recorded detailing the condition of sampling and any unusual observations during the sampling. These notes will help great deal during the processing of the sample and interpretation of the data. Please note, “ *good quality data collection and critical observations are an essential component of the sampling programme* “. A sample of the field data sheet is provided in appendix – I.

## 12. Labeling

Correct labeling of the sample is important as it ensures sample identification. Labeling should be clean, secure, water proof, non-smearing and with necessary information. It should be ensured that label should not get detached during the storage and transportation. Pens/ pencils used for labeling should be non-smearing and should maintain permanent legible mark. Label should contain, date, locality, sample code etc. Sample of the label is provided in appendix – II.

## 13. Key to common Genera of Chlorophyta

1. Plant hollow and tubular, one celled thick.....*Enteromorpha*.  
plant membranous .....2.
2. Plant membranous, 2 celled thick ..... *Ulva*.  
Plant sacate, monostromatic .....3.
3. Plant sacate, monostromatic with frilled margin.....*Monostroma*.  
Plant filamentous, unbranched thick cell wall .....4.
4. Plant filamentous, thick cell wall, basal cell long  
compared with the width, unbranched.....*Chaetomorpha*.  
Plant filamentous branched .....5.
5. Plant filamentous tufted branched,  
lower branches dichotomous .....*Cladophora*  
Plant erect, feather like, coenocytic. ....6.
6. Plant feather like, branched with precurrent  
axis, pinnately or radially branched, coenocytic .....*Bryopsis*  
Plant filamentous, netlike blade .....7.
7. Plant filamentous forming netlike blade  
with multicellular axis.....*Microdictyon*  
Plant filamentous, without forming blade .....8.
8. Plant filamentous, closely grouped, forming  
compact spongy thallus .....*Avrainvillea*  
Plant filamentous, closely grouped forming spongy plant.....9.
9. Plant filamentous, closely fused to form spongy plant .....*Codium*  
Plant coenocytious .....10.
10. Plant coenocytious organized to form  
stolon and erect branches .....*Caulerpa*.

- Plant erect, segmented ..... 11.
11. Plant erect, calcified form flabellated segments ..... *Halimeda*.  
 Plant erect, calcareous, dichotomous branches ..... 12.
12. Plant erect, calcareous, dichotomously branched, fan or  
 funnel shaped flabellum ..... *Udotea*  
 Plant multi-cellular calcified, branching in 1-3 forming whorl at  
 the top. .... 13.
13. Plant multi-cellular, calcified, branching in 1-3  
 whorls at the top of axis ..... *Acetabularia*  
 Plant solitary, pear shaped, grass green colour ..... 14.
14. Plant solitary pear shaped with fluid filled vesicle ..... *Boergesenia*.  
 Plant solitary bulb like, clavate vesicle ..... 15.
15. Plant solitary bulb like, clavate vesicle, slightly  
 constricted at the base, vesicle filled with fluid ..... *Valonia*  
 Plant solitary forming small colony ..... 16.
16. Plant solitary forming small colony, whitish  
 green colour with hairy tip. .... *Neomeris*

### 13.1 Key to *Ulva* species

1. Plants reticulate, netlike nature obscuring blade, mostly unattached entangled with other algae ..... *Ulva reticulata*  
Plants not reticulate, clearly blade like, mostly attached ..... 2
2. Plants normally divided into narrow segments; in transverse section cells along the paler central portion of the older segments much taller than those near the margins ..... *Ulva fasciata*  
Plants simple or with broad lobes ..... 3
3. Blades not naturally perforate; cells in transverse sections nearly square or taller than broad ..... *Ulva lactuca*

### 14. Key to common Genera of Phaeophyta

1. Plant filamentous, tufted, less than 5 cm tall ..... *Giffordia*.  
Plant filamentous branched ..... 2.
2. Plant filamentous, uniseriate branches, intercalary growth, sexual plant bears plurilocular gametangia ..... *Ectocarpus*.  
Plant filamentous, crustaceous, bears slender thread ..... 3.
3. Plant filamentous, crustaceous, bears slender bifercate with rudiment thread ..... *Sphacelaria*  
Plant filamentous, decumbent ..... 4.
4. Plant filamentous, decumbent below and erect above, sporangia lateral paraphysis in sori ..... *Ralfsia*  
Plant tubular, cylindrical or compressed ..... 5.
5. Plant tubular, cylindrical or compressed branching sparsely, pseudodichotomous ..... *Rosenvingea*  
Plant with expanded blade ..... 6.
6. Plant expanded, hollow spherical ..... *Colpomenia*

- Plant erect and spongy .....7.
7. Plant erect, net like spongy, sub-spherical  
to irregular, paranchymatous.....*Hydroclathrus*.  
Plant erect, branches without mid-rib.....8.
8. Plant erect, dichotomously branched with rounded  
apex, unilocular sporangia ..... *Dictyota*  
Plant broad, sparsely branched without mid-rib.....9.
9. Plant broad, erect, margin entire, branches  
irregularly dichotomus .....*Spatoglossum*  
Plant erect, dark brown, dichotomously branched .....10.
10. Plant erect, dichotomously branched, sporangia  
under surface of the blade .....*Stoechospermum*  
Plant erect branched with mid-rib .....11.
11. Plant erect, branched with distinct mid-rib,  
branching irregularly dichotomous .....*Dictyopteris*  
Plant entire, lobbed .....12.
12. Plant entire, lobbed, 2-8 celled thick marked with  
concentric row of hairs ..... *Padina*  
Plant erect, axis cylindrical bearing leaves and vesicles .....13.
13. Plant with erect axis, branched, leaves membranous,  
prominent mid rib, receptacles axially ..... *Sargassum*.  
Plant erect, branched, receptacles not axially .....14.
14. Plant moderate size, main axis and branches elongated,  
cylindrical or compressed, receptacles in the terminal branch .....*Cystoseira*  
Plant erect, branched, leaves turbinate .....15.
15. Plant erect, leaves turbinate consists of a subterate  
stalk, margin dented, receptacles in cluster ..... *Turbinaria*

## 14.1 Key to Dictyota species

1. Thallus flat with strap shaped branches,  
ultimate branching alternate .....*Dictyota dentata*  
Ultimate branching dichotomous or cervicorn,  
but sometimes also proliferous ..... 2
2. Thallus margin aculeate-dentate ..... *Dictyota ciliolata*  
Thallus margin shallowly srose-dentate .....*Dictyota jamaicensis*  
Thallus margin entire ..... 3
3. Branching essentially dichotomous throughout, but  
the division sometimes a little unequal in size ..... 4  
Branching ultimate cervicorn to irregular, though when  
plant is young almost completely dichotomous .....*Dictyota cervicornis*
4. Branches regularly spirally twisted, sinuses broad,  
wide-angled .....*Dictyota volubilis*  
Branches not consistently twisted ..... 5
5. Branches 1-2 mm broad or more below, but ultimately  
filliform at least above, often with an abrupt transition;  
sinuses wide-angled .....*Dictyota linearis*  
Branches broader, not narrowed above ..... 6
6. Internodal segments less than 4 breadth long;  
upper sinuses broad, ..... *Dictyota bartayresiana*  
Internodes longer; sinuses usually narrower ..... 7
7. Internodes 5-10 breadths long ..... *Dictyota dichotoma*  
Internodes 15 - 20 breadths long .....*Dictyota indica*

## 15. Key to common Genera of Rhodophyta

1. Plant erect, foliaceous, margin entire, magenta colour, stellate chloroplast with central pyrenoid .....*Porphyra*  
 Plant tufted, dichotomously branched .....2.
2. Plant tufted, dichotomous, repeatedly branched, mucilaginous moderately calcified .....*Liagora*  
 Plant erect, radially branched arising from stoloniferous portion .....3.
3. Plant erect, 10-20 cm tall, fronds plume, cylindrical, bare branches in lower third and densely branched pyramidal shape above.....*Asparogopsis*  
 Plant cartilaginous, axes erect, terate to compressed .....4.
4. Plant cartilaginous, terate to compress, saxicolous .....*Gelidium*  
 Plant slender, cylindrical stolon .....5.
5. Plant cartilaginous, erect, stolon give rise to erect and decumbent branches above and coarse short rhizoidal branches below, axial branches are cylindrical or compressed, stichidia are borne on the swollen tips .....*Gelidiella*  
 Plant bushy, wiry clumps .....6.
6. Plant bushy, wiry clumps, lower branches somewhat creeping, upper erect tapering towards the apex .....*Gelidiopsis*  
 Plant branched, axis cylindrical or flattened.....7.
7. Plant branched, flattened, structurally composed of central medulla surrounded by cortex .....*Gracilaria*  
 Plant cylindrical, profusely branched bearing short acute alternate branches .....8.
8. Plant erect radially branched, cylindrical, commonly beset with numerous thorn like branchelets. Tetraspores and cystocarps in swollen alternate branches.....*Hypnea*  
 Plant cylindrical slightly compressed ranches.....9.

9. Plant cylindrical with numerous cylindrical or slightly compressed branches, repeatedly dichotomous, monosporangia produced on monotheoid enlargement.....*Ahnfeltia*  
Plant more or less calcareous encrusted .....10.
10. Plant calcareous, epiphytic, genicula absent, hypothallum monostromatic, secondary pit connection lacking .....*Melobesia*  
Plant epiphytic, calcified, short apical segment .....11.
11. Plant calcified, epiphytic, forms fine thick pinkish clumps, apical segment shorter .....*Jania*  
Plant calcified, calcification absent at the node.....12
12. Plant calcified, branches regular to irregular, dichotomous, calcification absent at nodes .....*Galaxaura*  
Plant calcified, intergenicula swollen.....13.
13. Plant calcified, except at the node, cream colour, intergenicula slightly swollen .....*Amphiroa*  
Plant terate, flattened, solid or hollow .....14.
14. Plant terate, flattened, laterally branched, frequently lobbed or proliferous .....*Rhodymenia*  
Plant flattened, segmented.....15.
15. Plant branched, flattened, sometimes moniliform, segmented by diaphragm .....*Champia*  
Plant flat, broadly lobbed.....16.
16. Plant flat, broadly lobbed, divided longitudinally into narrow bands .....*Martensia*  
Plant foliaceous, irregularly branched, membranous with mid-rib .....17.
17. Plant foliaceous, irregularly branched, membranous

- with mid-rib.....*Caloglossa*  
 Plant branched, loment like segments.....18.
18. Plant cylindrical, flattened, radially or laterally  
 branched, constricted into laminated segment .....*Catenella*  
 Plant form bushy clumps, erect cartilaginous.....19.
19. Plant erect, reddish to greenish, main axis prominent,  
 determinate branches are arranged along the axis beset  
 with numerous spines.....*Acanthophora*  
 Plant erect, cartilaginous, wart like determinate branchlets.....20.
20. Plant erect, cartilaginous, determinate branches  
 beset with wart like branchlets .....*Laurentia*  
 Plant erect, cylindrical, determinate branches acute.....21.
21. Plant erect, cylindrical, delicate in texture, determinate  
 branches acute, stalked antheridia, oval cystocarp .....*Chondria*  
 Plant erect, polysiphonous axis.....22.
22. Plant erect, polysiphonous axis with 5 pericentral cells,  
 lateral branches alternate or whorled monosiphonous.....*Dasya*  
 Plant erect, axis monosiphonous.....23.
23. Plant erect, axis and branches at first  
 monosiphonous from apical cell, lateral develops into  
 several pericentral cells .....*Polysiphonia*  
 Plant terete, filamentous, dichotomously branched.....24.
24. Plant erect, filamentous, branched, axial filaments  
 corticated, nodes without spines .....*Ceramium*  
 Plant erect filamentous, node with row of spines.....25.
25. Plant erect, filamentous, node surrounded by a row of spines .....*Centroceras*  
 Plant erect, flattened to foliaceous .....26.
26. Plant erect, flattened with slippery blade, branches  
 pinnate to irregular, texture firm, dark purple colour .....*Grateloupia*  
 Plant cylindrical, variously branched.....27.
27. Plant cylindrical to foliaceous, simple or variously  
 branched, Tetra sporangia commonly present .....*Solieria*

Table: State wise seaweed species distribution along the West Coast of India.

Division	Family						Genera						Species					
	Gj	Mh	G	Ka	Kl	La	Gj	Mh	G	Ka	Kl	La	Gj	Mh	G	Ka	Kl	La
<b>Chlorophyta</b>	12	11	5	5	4	9	25	20	7	9	7	15	61	50	13	14	23	34
<b>Rhodophyta</b>	20	22	12	10	9	9	57	52	16	17	17	31	107	91	26	17	36	51
<b>Phacophyta</b>	10	7	6	6	2	4	27	17	9	10	3	12	58	44	23	18	7	21
<b>Total</b>	42	40	23	21	15	22	109	89	32	36	27	58	226	185	72	49	66	106

Gj- Gujrat, Mh-Maharashtra, G-Goa, Ka-Karnataka, Kl- Kerala,La-Lakshadweep.

## 16. References

- Taylor, W.R. (1957). Marine algae of the Northern coast of North America, Publ. The university of Michigan Press, Vol. I & II pp. 870
- Abboti, I.A. and G.J. Hollenber (1976) Marine algae of California. Publ. Stanford University Press. Stanford California pp. 827
- Untawale, A.G., V.K. Dhargalkar and V.V. Agadi (1983) List of marine algae from India. NIO Publ. pp 1- 46
- Fritsch, F.E. (1965) The structure and reproduction of the algae Cambridge university press Vo. I & II pp. 937
- Dwson E. and Michael S. Foster (1982) Seashore plants of California. University of California pres, Berkley Los Angeles London
- Srivasan, K.S. (1969) Phycologia Indica, Icons of Indian Marinine Algae. Botanical Survey of India, Calcutta. pp 52.
- Oza, R.M. & S.H. Zaidi (2001) A revised checklist of Indian marine algae. CSMCRI, Bhavnagar publication pp. 1- 296

## Field data sheet

Date :

Time:

Location (Lat.& Long.) :

(hand drawn sketch of the locality if possible)

Tide:

Cloud cover :

Atmospheric Temp. :

Water Temp. :

Water samples : Water quality estimation (DO, Salinity, pH, Turbidity, Nutrients)

Details of collection

a) Open coast

- i) sandy beach — 1. supra littoral, 2. intertidal, 3. subtidal
- ii) rocky beach —           "       "       "       "

b) Estuary

- i) mud flats
- ii) mangroves
- iii) rocky area

c) Type of transect :

d) Length of the intertidal expanse:

e) Frequency of sampling:

f) No. of quadrants at each transect :

g) No. of species recorded :

h) Dominant species :

i) % cover :

j) No. of quadrants for biomass estimation :

k) Associated fauna

i) No. of species (note the number of species separately) :

ii) Dominant species :

l) Field notes :

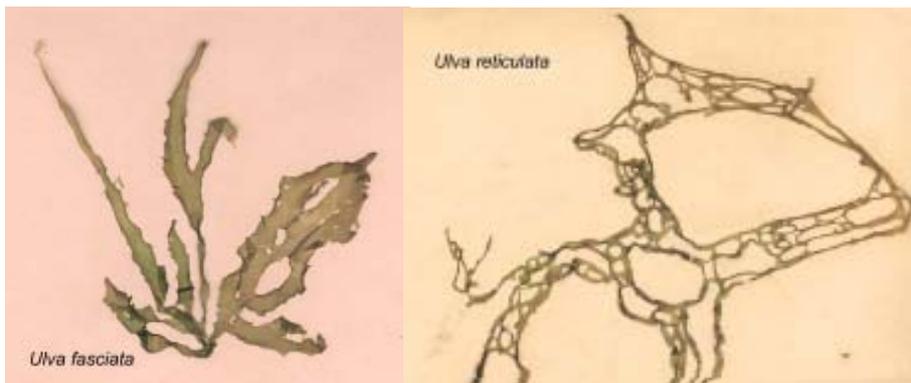
Appendix - II

NATIONAL INSTITUTE OF OCEANOGRAPHY

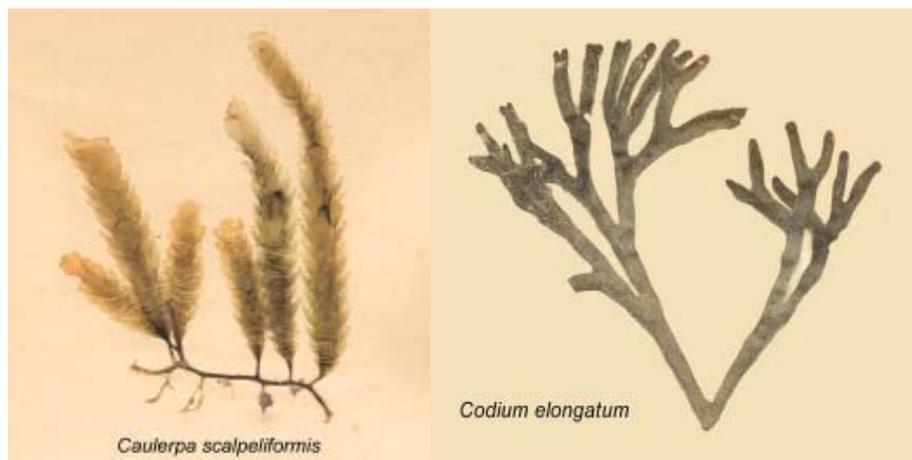
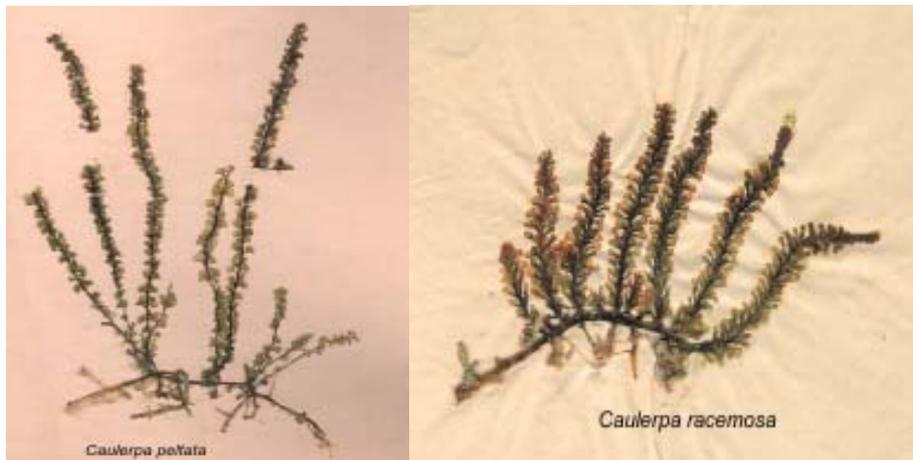
DONA PAULA, GOA 403 004, INDIA

serial No. 475 Date 22/10/1976  
Class Phaeophyta Family Scytosiphonaceae  
Genus Colpomenia  
Species sinuosa  
Common Name: Oyster thief Colour \_\_\_\_\_  
Locality Ratnagiri District Ratnagiri  
State Maharashtra Substratum \_\_\_\_\_  
Zone \_\_\_\_\_ Depth \_\_\_\_\_  
Exposure \_\_\_\_\_ Abundance \_\_\_\_\_  
Cruise No. \_\_\_\_\_ Station No. \_\_\_\_\_  
Latitude \_\_\_\_\_ Longitude \_\_\_\_\_  
Ecological Notes \_\_\_\_\_  
Remarks \_\_\_\_\_  
Collected by V.V. Agadi Identified by \_\_\_\_\_

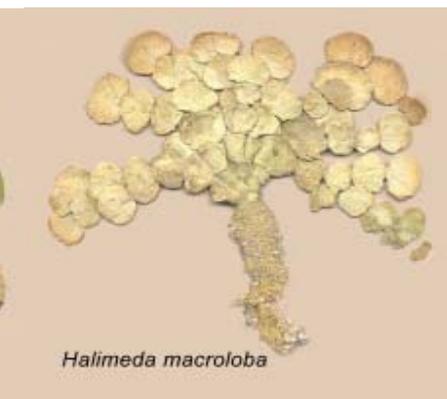
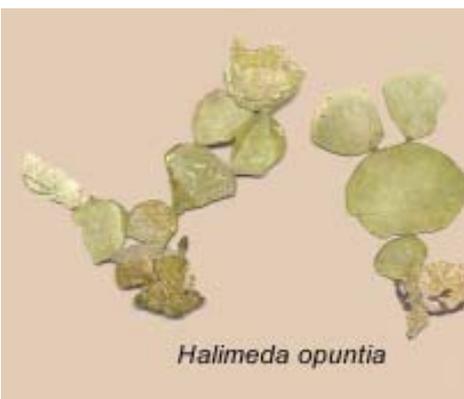
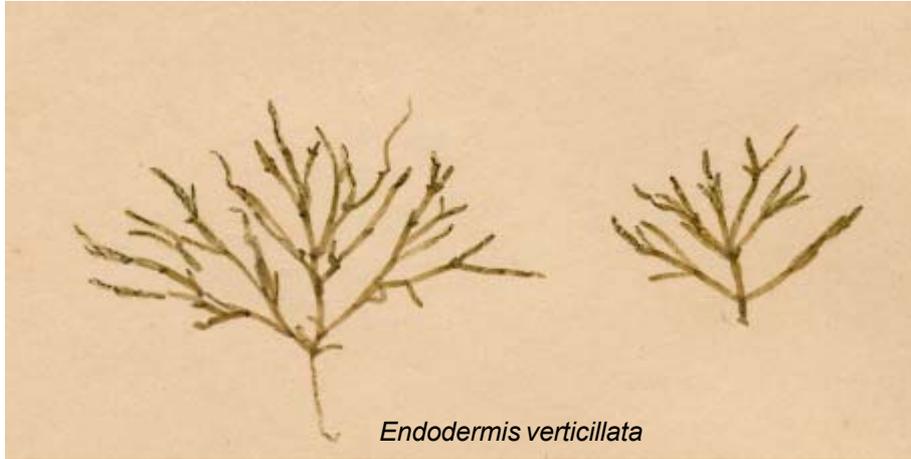
## Chlorophyta



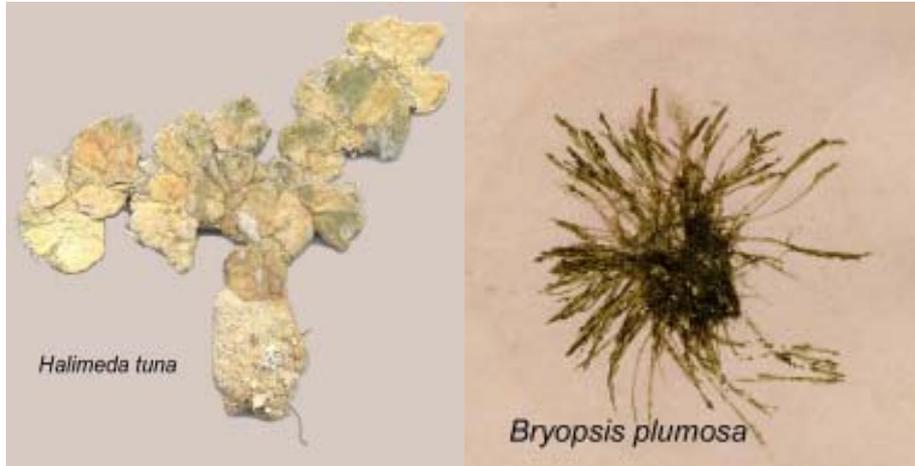
# Chlorophyta



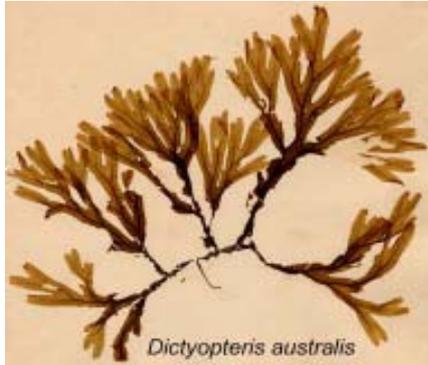
# Chlorophyta



## Chlorophyta



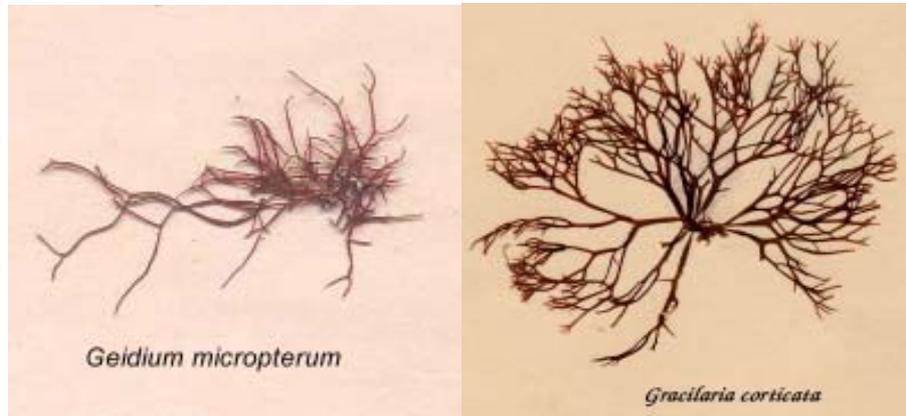
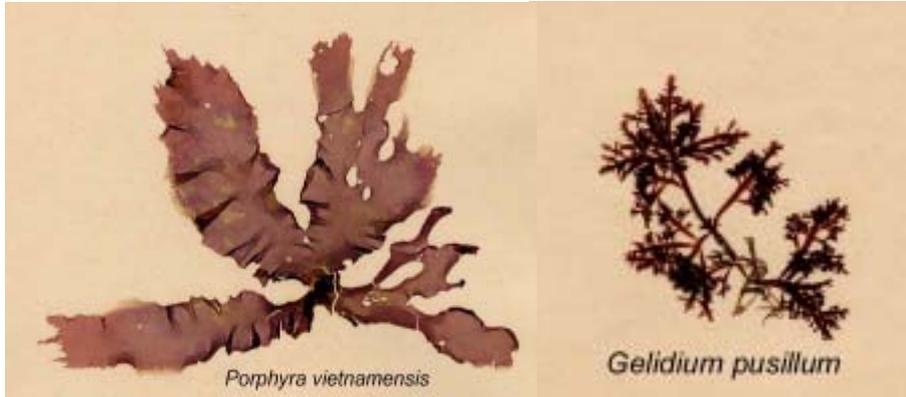
## Phaeophyta



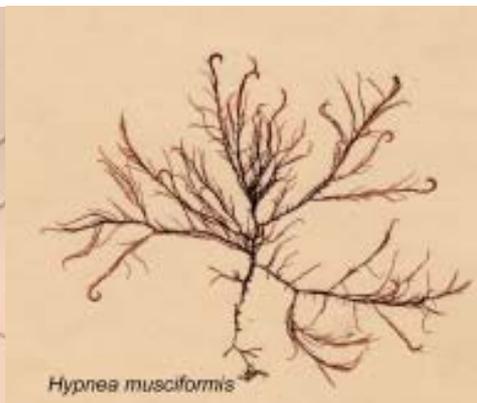
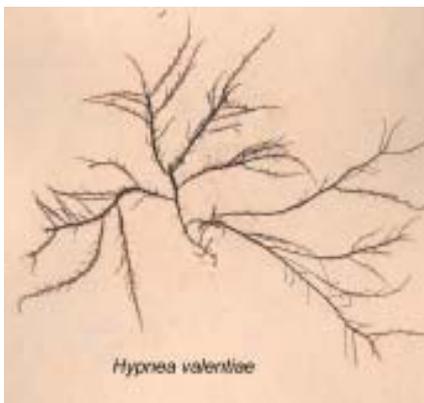
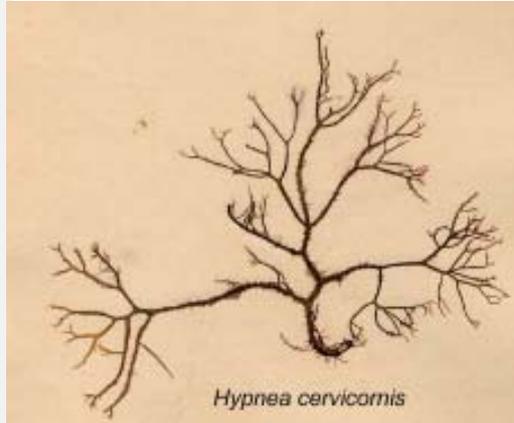
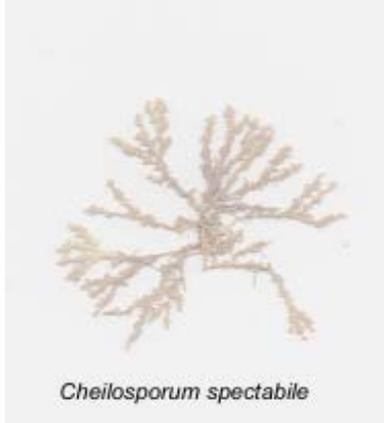
## Phaeophyta



## Rhodophyta



## Rhodophyta



## Rhodophyta

