Enhancing the Demands of AFNR Graduates Through Curricular Intervention Using Modular Approach with High S and T Content

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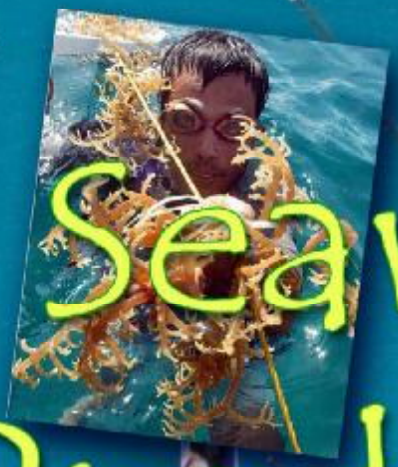
Module 7

Seaweeds Production



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Module 7: Seaweeds Production

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Those who shared their unbiased comments and suggestions.

Thank you very much!!!

MODULE DESCRIPTION

This training module deals with the basic information on the various cultivation techniques applied in the farming of seaweeds specifically on the *Kappaphycus* variety. These include the identification on the different *Kappaphycus* varieties, site selection, seedling preparation, farm preparation and construction, culture methods, and lastly, the rules and regulation governing seaweed farming.

Learners using this training module are students from the College of Fisheries and Marine Sciences taking up BS Fisheries, BS Aquaculture, BS Marine Technology, BS Food Technology and BS Marine Biology. Most of the students are in their higher years and has taken up some major courses in their respective program. Other schools offering related programs are welcome to use this learning module as it is prepared and written to accommodate non-marine related courses who would like to venture on seaweed production and become seaweed entrepreneur.

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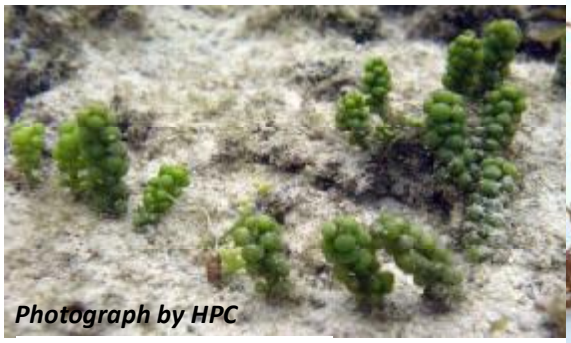
INTRODUCTION

Seaweed is an important component of the marine ecosystem along with the mangrove and coral reefs and which can be viewed in two perspectives: from its **ecological value** as well as its **economic uses**. Seaweed contributed about 27% to the total fisheries production in the year 2002, with Regions IV, IX and ARMM as major producers. This steady increase in production of seaweeds is being attributed to its high market demand and better price that in return encourage farmers to expand their areas for seaweed culture. In addition, the industry employs between 100,000 - 120,000 manpower in the country where 90% are seaweed farmers and the rest are seaweed processors and traders.

Solieria robusta

Seaweeds are exported either in **raw forms** (fresh or dried seaweeds) or **processed forms** (semi-refined chips/carrageenan and refined carrageenan). The Philippines is one of the top producers of seaweeds in the world, specifically the red seaweeds, *Kappaphycus alvarezii* (Doty) Doty ex Silva and *Eucheuma denticulatum* (Burman) Collins et Harvey. Both species have been farmed as materials for carrageenan production in the Philippines, Indonesia, Tanzania and more recently in other tropical countries like Brazil (Adnan & Porse, 1987; Doty, 1977).

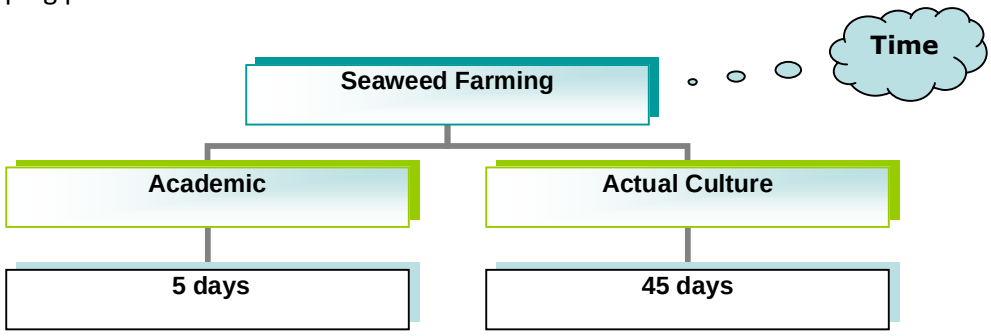


Caulerpa sp.

Kappaphycus alvarezii

Time Frame

As you go along this module, you will be exposed to the seaweed farming training course which is divided into two segments: academic training and actual culture. The academic training gives you the basic knowledge and culture techniques you need in farming seaweeds as an alternative livelihood. Though, test planting may also be conducted in the actual site for suitability and viability evaluation of the farming method that you will employ but this is optional. In the actual culture part, the module allows you to apply what you have learned during the academic training including the opportunity to experience actual management of a small seaweed farm for one cropping period.



Goals

The purpose of this module is to generally guide students in the Marine Fisheries, Aquaculture, Marine Technology and Marine Biology courses on the proper method of farming seaweeds. It also encourages students as well as for the unemployed graduates to be engaged in an entrepreneurial activity such as seaweed farming, as an alternative source of income while they are still studying or to venture in small seaweed farming business after graduation.

Learning Outcomes

Specifically, the learners are expected to:

- Identify good quality seed stocks for culture;
- Identify factors in the selection of a suitable site;
- Prepare the farm site and culture materials;
- Construct a seaweed farm; and
- Undergo culture and manage a *seaweed* farm.

Sub-Module 1: Introduction to Seaweeds

Overview

In this sub-module, you will be learning basic information that will help you understand and answer some basic questions related to seaweed farming. Among these are: what are seaweed, what are their major groups, what are the species of seaweeds that can be cultured and how are they important to seaweed farmer? These are topics presented to you as introductory concepts in relation to seaweed farming.

Learning Objectives

At the end of this sub-module, the participant will be able to:

- Define the term seaweed in terms of distribution and morphology.
- Classify seaweeds according to pigmentation and give at least five examples of each major broad group
- List various uses of seaweeds and its application to industry
- Identify the different *Kappaphycus* varieties commonly used in seaweed farming
- Explain why seaweed farming is important to coastal communities

1. What are Seaweeds?

Seaweeds (also called **macrophytes** or **macroalgae**) are simple plants growing mostly in shallow areas of the sea and are known commonly as marine algae. Botanist describe them as very simple plant mainly because they don't have true roots, true stems and true leaves that land plants have. Though some of them have root-like structures called holdfast, but this is only used to attach them to hard substrate. They are able to absorb required nutrients from the surrounding waters through their thalli.

They still lack the complex structures and reproductive mechanisms characteristic of higher plants, hence, most botanists placed **seaweeds** under Kingdom Protista. They are divided into three broad groups based on their pigmentation: Class

Chlorophyceae (green algae), Class Rhodophyceae (red algae) and Class Phaeophyceae (brown algae) (Fig.1). Naturally growing seaweeds are often referred to as wild seaweeds, in contrast to seaweeds that are cultivated or farmed.

In addition, seaweeds grow in all shallow waters where sufficient sunlight is available. They serve as food and provide shelter for many marine animals in coastal ecosystem. Many of these species are directly important to human as food and for industrial raw materials. Extraction of seaweeds can be in the form of agar (for confectionery and desserts), carrageenan (for salad dressings and sauces), and algin (pharmaceutical industries). Referring to wide variety of seaweed uses, the farming of seaweeds is an important aspect for economic benefits.

Caulerpa sp.
Green Algae (Class Chlorophyceae)

Kappaphycus alvarezii
Red Algae (Class Rhodophyceae)

Turbinaria conoides
Brown Algae (Class Phaeophyceae)

Figure 1. Major Groups of Seaweeds

Activity 1

Survey of Marine Macroalgae

Macroalgae usually thrive in shallow rocky shores, reef areas and seagrass beds where sunlight and nutrients are abundant. The algae differ in their pigmentation and yet they can multiply rapidly. They serve as the primary producers of the sea.

In this activity, you will be given different samples of fresh seaweeds. You will identify and group them according to their taxonomic classification using the references of Calumpong and Menez (1997) and Trono (1997).

Objectives:

- Identify the common macroalgae in an intertidal area (representative algae of each Division)
- Classify each specimen (Class, Genus, Species)

Procedure:

1. Make sketches of each specimen.
2. Classify the specimens based on their characteristic color. Identify them at least to the genus level. Give also the common names.

Class Rhodophyceae **(Red Algae)**	**Class Phaeophyceae** **(Brown Algae)**	**Class Chlorophyceae)** **(Green Algae)**
Ex. 1. *Eucheuma* sp. Common Name: guso	Ex. 1. *Sargassum* sp. Common Name: ___	Ex. 1. *Caulerpa* sp. Common Name: lato

Review Questions:

1. What structural characteristics are common to all algae?

_____

_____

2. Describe the role of algae in the marine ecosystem.

_____

_____

_____

2. Economic Importance of Seaweeds

Seaweed has been cultured traditionally for decades and probably for centuries in several Asian nations such as China, Korea and Japan. In the Philippines, seaweed farming has become a well developed industry for over three decades. It is a significant export earner as well as an income and employment generator in coastal communities where it is practiced. Seaweed is exported in two forms: raw seaweed or carrageenan. The Philippines, together with Indonesia, Malaysia (Sabah), Fiji and Tanzania are some of the commercial producers of carrageenophytes today, selling quantities of 1000 metric tons or more on a substantial continuous basis. In these countries seaweed farming has become a livelihood in coastal fishing communities, generating a cash income for more than 1500 fishing families in Indonesia, 80,000 in the Philippines and 400 in the Republic of Kiribati (Hurtado *et al*. 2001).

Hence, seaweeds are very important not only for their biological roles in the marine environment but also for the economic benefits that they directly provide to the human population. Dawes, 1987 Trono and Fortes (1988) summarized the uses of seaweeds as follows:

2. 1. As direct source of food

Japan, China, Philippines, Korea, other Asian countries and Hawaii consume seaweeds directly as food. They are mostly harvested from natural populations but mariculture of important species has been practiced specially in the first three countries mentioned. The species that are marketed and sold daily in the Philippine wet markets are the *Caulerpa lentilifera, C. racemosa, Eucheuma alvarezii, E. denticulatum* and *Gracilaria verrucosa* which are prepared in the form of salads or utilized for other culinary purposes. *Porphyra* or "Nori" is a regular part of Japanese meal. The browns *Laminaria* and *Alaria* are also popular food items in Japan and Korea. Locally, Zamboanga City boasts its fresh sea vegetables in the form of salad with *Caulerpa*, *Kappaphycus* green variety

and *Solieria* species commonly called in the local dialect as "latu", "agar-agar" and "gulaman", respectively (Tito and Liao, 2000). Presently, the most expensive edible seaweed in Japan is *Monostroma*. It is also farmed like the previously mentioned seaweeds but “Nori” remains the most extensively cultured.

2. 2. As medicine

Seaweeds have been variously utilized as medicinal herbs. Early Roman soldiers have used species to heal wounds, burns and rashes. Goiter and other internal disorders have been treated or prevented with seaweeds by Chinese and Japanese. **Agarophytes** (red algae which contain agar, e.g., *Gracilaria*, *Gelidium*, *Porphyra* and *Hypnea*) and **carrageenophytes** (red algae containing carrageenan e.g., *Eucheuma* spp. and K*appaphycus* spp.) are good laxatives (Calumpong, 1981). *Digenea simplex* has been reported to be a good vermifuge or medication to get rid of worms (Trono, 1973).

2.3. As fertilizer, fodder and fuel

Aqueous extracts from brown seaweeds have been used commercially for agricultural purposes (Stephenson, 1974; Montano and Tupaz, 1987). Fertilizers from seaweeds result to increased crop yield probably due to the presence of growth promoting hormones (Bentley-Mowat, 1963). Other beneficial effects include increased resistance of crop to fungal and insect pests and increase water holding capacity of the soil (Mathieson, 1967). In Europe, seaweeds are dried and grounded to produce meals for animals. *Macrocystis, Sargassum* and *Gracilaria* are sources of fuel (methane), production of which is now a new-venture especially in the United States.

2.4. As sources of phycocolloids

Polysaccharides extracted from seaweeds (especially reds and browns) that can form colloidal or gel systems in water are called phycocolloids. *Alginic acid* is a polymer of D-mannuronic and L-guluronic acids and is derived from brown seaweeds. **Alginates** are used as emulsifier and stabilizers in the textile, paper, paint and food industries. They have been used to make surgical threads and whole blood substitutes for emergency transfusion. Half of the entire world production of alginic acid comes from the harvesting of *Laminaria* in the North Atlantic. Other sources are *Eclonia* and *Sargassum* in the Pacific and Indian Oceans.

Agar which chemically consists of agarose and agaropectin is a strong gelling phycocolloid mostly extracted from *Gracilaria, Gelidium, Gelidiella* and *Pterocladia.* The better quality agar is used as medium for culture of microbiological specimens. The food industry uses them as protective gels in canned meat and stabilizers in many bakery products. They are also used in the sizing of fabrics, water proofing of paper and cloth and/or clarifying agent in the manufacture of wines, beers and coffee.

Carrageenan are large, highly flexible molecules which curl forming helical structures. This gives them the ability to form a variety of different gels at room temperature. This phycocolloid is used mainly in dairy products because of its stabilizing effects with milk proteins. It is also useful in the production of toothpaste, diet foods, soups and confections. Other products with carrageenan as suspending or gelling agent are those from the cosmetic, paint and pharmaceutical industries.

Three main commercial classes of carrageenan:

a) **Kappa:** forms strong, rigid gels. Gels with potassium ions, react with dairy proteins. Mainly from *Kappaphycus* species.
b) **Iota:** forms soft gels. Gels with calcium ions. Produced mainly from *Eucheuma denticulatum*
c) **Lambda:** does not form gel. Gels can be formed when mixed with proteins rather than water. It is used to thicken dairy products. The most common source is *Gigartina* from South America.

Application and Uses of Carrageenan:

- **Desserts, ice cream, sweetened condensed milks, sauces**: gel to increase viscosity
- **Beer:** clarifier to remove haze-causing proteins
- **Pâtés and processed meat:** Substitute fat to increase water retention and increase volume
- **Toothpaste:** stabilizer to prevent constituents from separating
- **Fruit Gushers:** ingredient in the encapsulated gel.
- **Fire fighting foam:** thickener to cause foam to become sticky
- **Shampoo and cosmetic creams:** thickener
- **Air freshener gels**
- **Shoe polish:** gel to increase viscosity
- **Biotechnology:** gel to immobilize cells/enzymes
- **Pharmaceuticals:** used as an inactive excipient in pills/tablets
- **Carrageenan:** used to thicken skim milk, in an attempt to emulate the consistency of whole milk. This usage did not become popular. It is used in some brands of soy milk
- **Diet sodas**
- **Soy milk**
- **Pet food**
- **Personal lubricants**
- **Lambda carrageenan** is used in animal models of inflammation used to test analgesics, because dilute carrageenan solution (1–2%) injected subcutaneously causes swelling and pain.

3. Seaweed Farming in the Philippines

In this section, seaweed farming is described, its importance to coastal community and the seaweed species being cultured in the Philippines. As you go along in this module you will realize that you can be a seaweed entrepreneur.

Seaweed farming is a way of cultivating seaweed in specified areas by any method with an appropriate intensive care for commercial production. The activity is suited for both men and women. Most seaweed farming is low technology and suited to the lifestyles of rural coastal villagers who may have few income generating opportunities. It has become an important and major livelihood in the coastal fishing communities, generating a cash income for more than 1500 fishing families in Indonesia, 80,000 in the Philippines and 400 in the Republic of Kiribati (Hurtado *et al.* 2001).

Seaweed farming does not require high investment, but the return is high. The yield from a one-hectare seaweed farm can be as much as 48 tons (wet weight) in two months (Guerrero, 2001).

Why would I go into seaweed farming?

- ✓ High return of investment
- ✓ Sure market (high demand for seaweeds in both local and international markets)
- ✓ Short culture period: 45 days under optimal conditions
- ✓ Environment friendly

Production Cycle

1. Farm construction and support system
2. Seed stock preparation
3. Planting
4. Harvesting
5. Post harvest activities
   (drying)
6. Packing dried seaweeds

Because of their carrageenan content, *Euchema* and *Kappaphycus* spp are the world's most sought-after species. Hence, seaweed farming in the Philippines has focused on these two species where it produces most of the world's demand for carrageenan tossed by 16 processing plants in Cebu, Manila and Zamboanga, including new plants in Davao and Bukidnon provinces. Seventy-five percent (75%) of the country's supply of *Euchema* and *Kappaphycus* are from Zamboanga and Sulu archipelagos. These include the coastal areas of Western Mindanao, the island provinces of Tawi-Tawi, Sulu, and Basilan, the provinces of Zamboanga del Sur, Zamboanga del Norte and Zamboanga Sibugay and Zamboanga City. The Philippine carrageenan industry needs at least 134,000 metric tons of dried seaweed yearly.

There are two species in sixteen (16) varieties of *Kappaphycus* being cultured in the different regions around the Philippines (see Fig. 1.2). Each variety of *Kappaphycus* requires restricted suitable condition for it to perform better in terms of growth and survival. Two varieties of *Euchema denticulatum* are also grown in some farms.

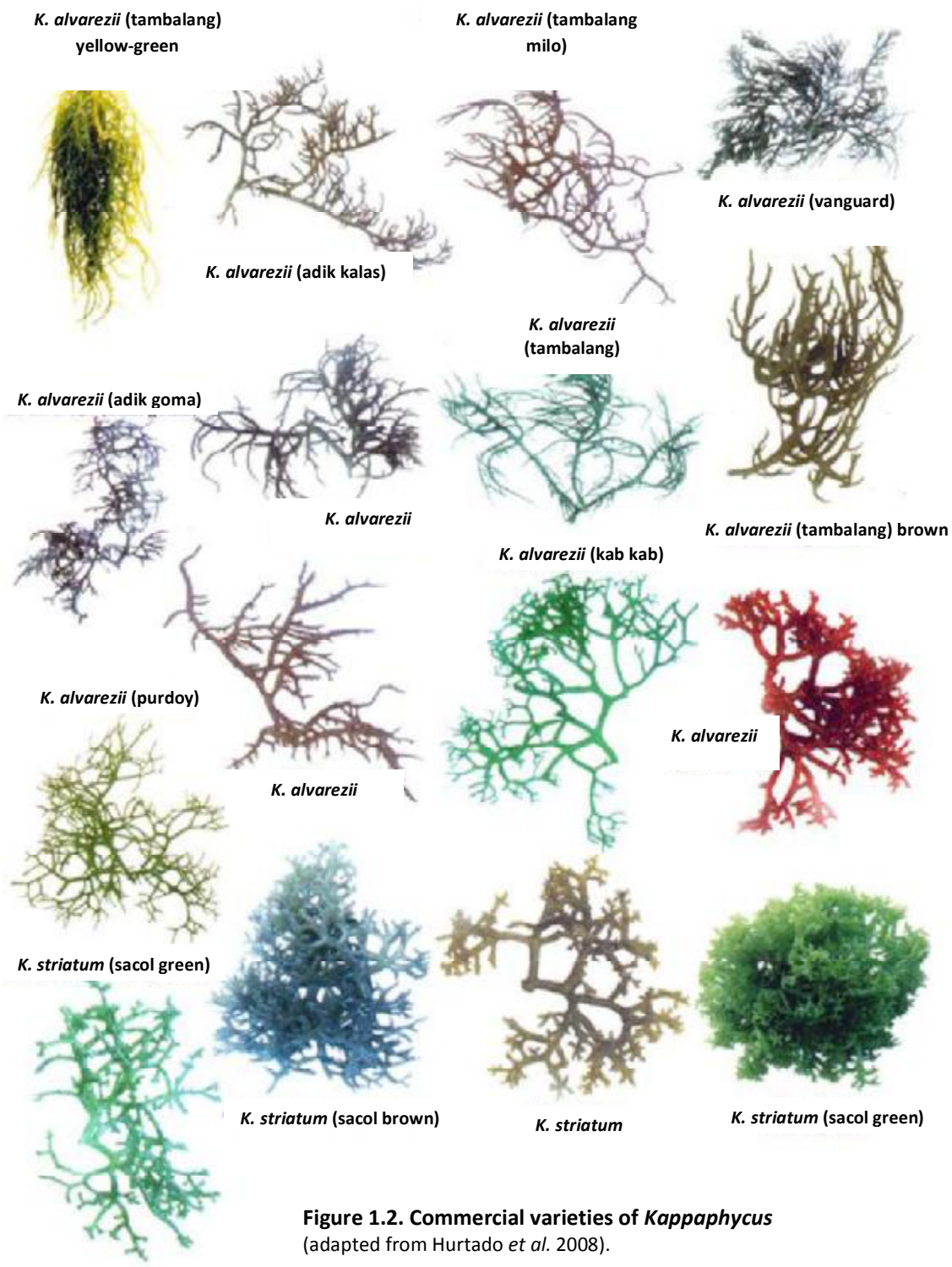


Figure 1.2. Commercial varieties of *Kappaphycus*
(adapted from Hurtado *et al.* 2008).

Different Varieties of *Kappaphycus*

There are two species in 16 varieties of *Kappaphycus* and two varieties of *Eucheuma denticulatum* that are farmed in the Philippines. This activity will familiarize you with these species and varieties.

Activity 2

Objectives:

- Identify the different varieties of *Kappaphycus* and *Eucheuma* farmed in the coastal waters of Zamboanga Peninsula
- Determine the distinguishing characteristic of each variety.

Procedure:

1. Collect samples from the market and local farms.
2. Using Figure 1.2 in this module, identify the varieties you have collected.
3. Make sketches of the different varieties.
4. Point out the identifying characters of each variety.

Review Questions:

1. What are the different varieties of *Kappaphycus* found in your locality?

_____
_____
_____

2. How do the varieties differ from each other?

_____
_____
_____

Sub-Module 2: Biological and Ecological Aspects in Seaweed Farming

Overview

The ambient ecological condition in a certain habitat is the result of the combined and synergistic effects of the various ecological factors. Some of these factors may exert modifying effects on the others. Your understanding on the influence of these parameters to the nature, biology and distribution of seaweed is very important in the evaluation and assessment of sites in the farming of seaweeds

Learning Objectives

At the end of this sub-module, the participant will be able to:

- Identify factors that influence productivity in a seaweed farm.
- Distinguish between biological and ecological factors that influence the productivity of a seaweed farm.
- Explain how biological and ecological factors affect seaweeds productivity.

1. Environmental Factors

1.1. Salinity

Salinity is defined as "the amount of solid materials in grams contained in one kilogram of seawater when all the carbonate has been converted to oxide, bromine and iodine replaced by chloride and all the organic matter completely oxidized".

Most seaweed species cannot withstand exposure to a wide variation in salinity regimes while others can. Those which cannot tolerate wide range of salinity regimes are known as **stenohaline** species while those which can are called **euryhaline** species. The effects of salinity on the structure of seaweed communities may be best illustrated by comparing the variety of species found in habitats which are influenced by freshwater (brackish) with those far from freshwater sources. Areas influenced by freshwater are generally characterized by low species diversity compared to reef areas not influenced by low salinity.

The low diversity may be mainly due to the fact that only few species can thrive in habitats with highly fluctuating salinity regimes. For instance, certain species like *Glacilaria verrucosa* thrives very well in brackishwater areas while other species will die in such habitats.

1.2. Light and temperature

All photosynthetic plants require light as source of energy for the synthesis of organic products necessary for their normal growth and development. The different groups of seaweeds possess pigments of various types which enable them to adapt to different light conditions in the sea.

The quality and intensity of light change as it penetrates the water column. The change in light quality and intensity affects the distribution of the various species. The influence of light on seaweed distribution is best illustrated by their vertical zonation. In general those with pigments adapted for low intensities may be found in deeper areas while those adapted to full or bright conditions are found in shallow areas.

Heating of the water is a secondary effect of light which also affect the local distribution of seaweed species. Such effects, however, are limited to shallow intertidal areas or tidepools which become isolated and are not influenced by free water circulation. In such habitats, the temperature may become very high and can cause the exclusion of many species from the area. Such pronounced increase in water temperature takes place especially when low tides occur during the day. There is no significant change in water temperature in deeper areas where the water is constantly mixed by currents or wave action.

1.3. Water movement

Water movement is an overall primary factor which controls or influences the nature or status of seaweed communities as well as modifies or moderates the extreme effects of other ecological factors. Water movement caused by waves and currents is important in aeration of the water, nutrient transport and mixing which prevents the rise in water temperature as well as light penetration. It also influences the amount of harvestable seaweed stocks. Waves are known to mechanically remove significant amounts of seaweed stocks. This effect is best illustrated by the tremendous amounts of drifted seaweed materials which accumulate along the beaches after storms. Wave-exposed areas are not good sites for the mariculture of seaweeds because of the

destructive effects of waves on the farm. On the other hand, areas influenced by moderate currents are preferred sites for farming of certain species such as *Eucheuma* because currents are less destructive. Productive seaweed farms in the Philippines are characterized by moderate to strong currents. Loss of plants due to removal by currents can be significantly controlled by the construction of catchments at the lee-ward side of the farm.

1.4. Water depth

The **water depth** is another important factor which influences the local abundance and distribution of seaweeds. The upper limit of the vertical distribution of seaweeds is closely related to the upper tidal levels while the lower limit is limited by the amount of light which penetrates the water column. In general, most seaweed communities are well-developed starting from approximately plus or minus the 0 datum level to a few meters below this depth. The upper limit of vertical distribution of seaweed is influenced by the amount of exposure to air and sunlight during low tides and the inherent capacities of the species to resist desiccation and the complications brought about by changes in salinity and water temperature during such exposure. The lower limit is generally related to the light conditions. Few species can thrive well in very low light intensities in deeper areas. The understanding of the role of water depth in the vertical distribution and growth of seaweeds has a very important bearing in the selection of good sites for seaweed farms.

1.5. Substratum

Substratum provides mechanical support or attachment of the seaweeds. Seaweeds have different types of attachment organs adapted to various types of substrata. For those species in the sandy-muddy habitats, they generally posses fine and penetrating rhizoidal holdfasts while those in solid, hard or rocky substrates posses strong branching or discoid holdfast. Hence, different substrate types influence the composition and distribution of seaweed species. For farmed seaweed, seedlings are manually tied and are harvested before they can develop holdfast.

1.6. Biotic factors

One of the ever present factors which control marine vegetation are the **associated animal life**. Seaweeds and seagrasses are constantly being grazed

upon by a host of **herbivorous** animals. These animals significantly control the amount of harvestable organic matter (biomass) in reef areas. Studies have shown that when grazing is controlled by the physical destruction or removal of grazers, luxuriant growth of seaweeds would follow.

Fungal and **bacterial** diseases are recognized as important biotic factors which influence the productivity of seaweed communities. These two factors are important considerations in the farming of seaweeds. Seaweed crops may be completely lost due to the destructive effects of these biotic factors. The presence of "weeds" is also one of the major problems in farms. These unwanted seaweed species compete with the crop plants for nutrients, space and light.

2 Site Selection

The most important aspect in developing a potentially productive seaweed farm is site selection. Based on the information discussed in the previous topic, as a farmer you must assess the area to evaluate the suitability for growing seaweeds.

Seaweed production depends largely on the specific environment; one needs to identify and locate the most suitable areas for seaweed farming. The search for a suitable area is the most difficult task encountered by seaweed farmers because of the very delicate nature of the plant. The following are some guides for you to be able to select a good site for seaweed farming:

1. The area should have good water movement or rapid water turnover, but not intense enough to damage the farm. Water current speed should be between 20 to 40 meters per minute.
2. Area should be sheltered from very strong wave action, current and wind.
3. Avoid areas that are near the mouth of rivers or where there is a heavy freshwater runoff. *Kappaphycus* and *Eucheuma* are marine alga. Salinity of the farm area should be from 27 to 35 parts per thousand.
4. The area should have a water temperature range between 25°C and 30°C.

5. Water depth in the farm should not be less than 2 feet during the lowest tide and more than 7 feet during high tide (only applicable in shallow stake or monoline method).
6. The ground should be stable enough to permit easy installation of stakes.
7. Farm bottom composition should be sandy and rocky depending upon the variety of seaweeds you are farming.
8. If possible, choose areas where *Kappaphycus* or *Eucheuma* are endemic. However, the absence of such is not necessarily a negative sign.
9. Take note of the other marine plants and animals that are associated with *Kappaphycus* or *Eucheuma*, for they are good indicators of possible site for farming.
10. Consider also the availability of labor, materials, accessibility to transportation and communication as well.

Generally, there is no way of determining the appropriateness of the area unless actual testing is done. The level of productivity of the selected area or locality cannot be accurately ascertained until a history of growth rate has been established. Once the site is pinpointed, the task of production will be relatively easier.

Physical and Chemical Parameters of Seawater

Activity 3

The growth and survival of any seaweed species (ultimately, seaweed production) depend on the physico-chemical characteristics of the marine environment. This exercise is designed to acquaint you with some techniques in monitoring the salinity, temperature, pH, transparency, water current speed/velocity and dissolved oxygen of the seawater. These techniques however, are not a requirement for one who aspires to do seaweed farming since these data can be obtained from institutions (e.g., BFAR, PAGASA & academe) who do environmental monitoring. This exercise simply will serve as additional tools to extend your understanding of the marine environment.

Objectives:

- Measure and record some physical and chemical parameters of seawater.

Materials & Instruments: refractometer, thermometer, pH meter,

drogue (or meter stick, 2" x 2"styropore, watch),

Secchi disk

Procedure:

1. Visit at least two coastal areas nearby.
2. Using the different field equipments, determine the salinity, temperature, pH, transparency, water current speed/velocity and dissolved oxygen. Readings/measurement should be done in three trials.
3. Record your results.

Site 1

Parameters (unit)	Name of Study Site:_____			
	Trial 1	Trial 2	Trial 3	Average
1. Salinity (ppt)				
2. Temperature (°C)				
3. pH				
4. Transparency (cm or m)				
5. Current velocity (m/s)				

Site 2

Parameters (unit)	Name of Study Site:_____			
	Trial 1	Trial 2	Trial 3	Average
1. Salinity (ppt)				
2. Temperature (°C)				
3. pH				
4. Transparency (cm or m)				
5. Current velocity (m/s)				

Review Questions:

1. Define the following:
   a. Salinity –
   b. Temperature –
   c. pH –
   d. Dissolved oxygen (DO)-

2. Which site is suitable for seaweed farming? Why?

_____
_____
_____

Sub-Module 3: The Farming Techniques

Overview

Some seaweeds can be cultivated vegetatively, others can only do so by going through a separate reproductive cycle, involving alternation of generations.

In vegetative cultivation, small pieces of seaweed are taken and placed in an environment that can sustain growth. When they have grown to a suitable size they are harvested, either by removing the entire plant or by removing most of it but leaving a small piece that will grow again. When the whole plant is removed, small pieces are cut from it and used as seed stock for further cultivation.

The success of your *Kappaphycus* farm does not only depend on the site but also on the method of farming that you will adopt. This portion deals only on the methods of farming that are proven to be economical, easy to construct, manage and maintain.

Learning Objectives

At the end of this sub-module, the participant will be able to:

- List the different culture techniques used in seaweed farming.
- Differentiate between fixed-off bottom and floating method in the culture of seaweeds.
- Describe the two floating method for deep sea seaweed farming.
- List the materials needed in the construction of a seaweed farm.
- Identify factors in the selection of farm site.

1. TYPES OF FARMING

1.1. The Fixed off-Bottom Monoline Method

The fixed, off-bottom monoline method or simply bottom line method of cultivation is commonly used in commercial farms (Figure 3.1.). This method has many advantages over other methods such as the net method used in the past.

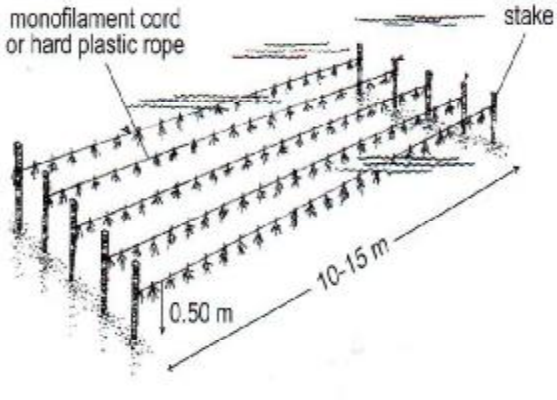


Fig.3.1. Fixed off-bottom line method

Construction of the farm support system starts with knocking holes in the substratum using a pointed iron bar and heavy bull hammer. Pointed wooden stakes are firmly driven into the holes in the substratum using a bull hammer. The stakes are arranged in rows at 1 m intervals, and distance between rows is 10-15 m apart. A loop is made at one end of the monofilament line and is attached to a stake. The line is then stretched tightly and the other end tied to a stake in the next row. The distance of the lines from the ground is adjusted to the depth of the water during low tides so that the plants are not exposed to air and sun. The lines are generally positioned parallel to the direction of the current or waves. An additional support stake may be placed midway between the original rows of stakes to prevent the lines from sagging.

1.2. Floating Method

These methods are used in deeper areas as well as in shallow areas that are characterized by weak water movement or where the bottom topography is irregular. The floating long lines have two major variations – single and multiple. In the single variant, 100 m nylon ropes (3-4 mm diameter) are used as main support lines, both ends of which are anchored to the substratum. The level of the lines in relation to the surface

of the water column is determined by adjusting the length of the line of the floatation device. Single floating lines are distanced some 5-8 meters apart to avoid them from becoming entangled. The floating method has two subtypes:

a. Floating Monoline Method

This method uses monofilament lines to which cuttings are tied approximately 20-25 cm from each other. Wooden posts are driven to the bottom, 10 meters apart in rows and a meter between rows (Figure 3.2). The lines are tied at both ends of the posts parallel to each other. Modifications to this method involve supplementary lines tied to the anchors for additional support – spider web method (Figure 3.3).

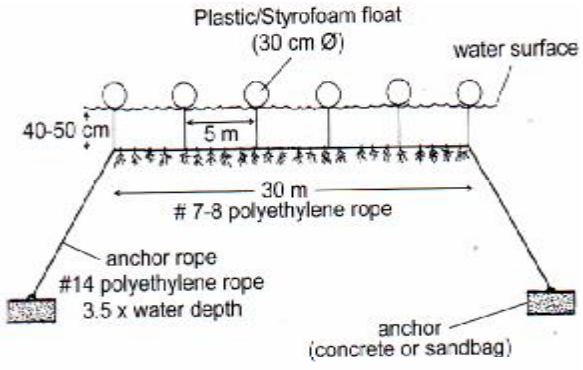


Figure 3.2. Floating monoline method

The floating monoline method has the following advantages over the fixed, bottom monoline method:

- Grazing by bottom-associated animals is minimized or eliminated because the plants are raised out of reach of benthic grazers
- Plants near the surface of the water column

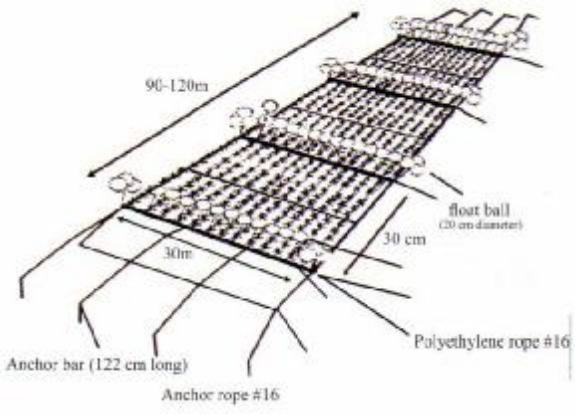


Figure 3.3. Spider Web Method

are exposed to a more moderate water movement caused by waves.

b. Raft Method

In the raft method, the monolines are attached to a wooden or bamboo frame, the size of which varies depending on the available frame materials. The monolines are attached to the frame parallel to the length of the frame at 20-30 cm intervals. A 4 x 5 m raft unit may be planted with 350-400 cuttings. The units are anchored to the substrate from their corners, using nylon ropes (Figures 3.4 and 3.5). Floatation materials are attached to the corner of the rafts to increase their buoyancy.

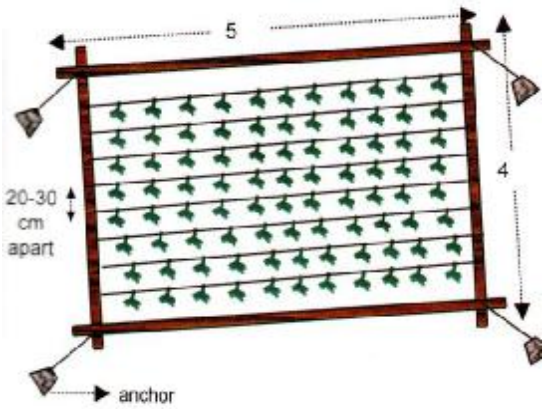


Figure 3.4. Raft Method (floating)
(Adapted from Trono et.al 2000)

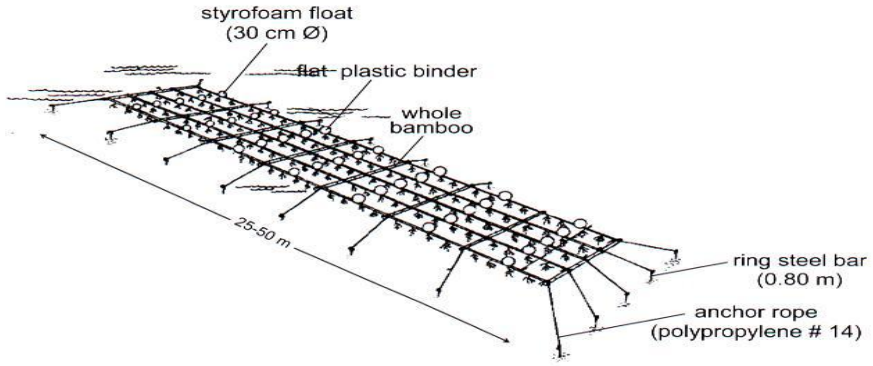


Figure 3.5. Multiple Floating Raft Long–line method (adapted from Hurtado *et al.* 2008)

MATERIALS REQUIRED FOR SEAWEED FARM

- iron pegs measuring more or less 1 inch in diameter and 1 meter in length
- nylon line number 150 to 200
- plastic tie straw
- one banca
- seedlings weighing from 150-200 grams each (total of 6.000 kg)
- markers and signboard
- seedling bed at least 25 square meters or a floating bamboo seedbed.
- pointed iron bars locally called “baras”
- bull hammer weighing 5 kilograms

2. SEEDLING PREPARATION AND PLANTING

Seedlings should come from a variety that has been proven to grow fast in the area. It must also come from the nearest source to avoid higher mortality and expenses when transporting to the area. Before hand, a seedling bed should have been prepared already before any transport to the area is done. This structure will serve as a storing place of seaweed seedlings before planting.

The transport of seedlings is the most risky part of the process. The factors to consider are: exposure to direct heat, wind, over-handling, and length of time off seawater. Seaweed seedlings will die once they are off the water for more than 12 hours and without pouring seawater into them in-between. If the seedlings are placed in a container with inadequate ventilation, packed with too much pressure or there is an increase in temperature in the container, seaweed seedlings wilt and die. Other factors such as when they are dipped in or wet with fresh water or rain or any other liquid aside from seawater, they will die due to changes in salinity.

The manners of transporting seedlings commonly used and recommended are:

1. If transport of seedlings requires eight (8) hours or less, the use of bamboo basket or wider banca is recommended. Covering them with cloth wet with

seawater is advised to avoid direct exposure to sunlight and/or wind. To maintain the temperature and the freshness of the seaweeds, wet them by pouring fresh seawater every one to two hours.

2. When the time required is more than eight (8) hours but less than 36 hours, then use jute bags. Place the seedlings loosely inside the bags and dip it in seawater before loading them. While on transport, pour fresh seawater to the bag every three to four hours to maintain the temperature and the freshness of the seaweeds. These bags should be placed in cool, well covered and spacious portion of the boat. Do not stack or place the jute bags on top of the other.
3. When seedlings are transported for more than 36 hours, it is advisable that a plastic bag with corals and coarser sand inside is advisable. However, this type of transport is not recommended for commercial farming because it is expensive.

Upon arrival in the farm site, all transported seedlings should be placed immediately in the seedling bed. However, it is advisable that the seedlings are planted immediately since storing the seedlings in the seedling bed for additional days will cause them to die especially when they are placed close to each other. The usual minimum mortality on transported seedlings is 20 to 30 percent.

The unsplitted seedlings are first divided and cut to desired weight (150-200 g) and size. Tie the seedlings with soft straw and place them in a separate container. There are three common ways of tying the planting material or seaweed cuttings to nylon lines (Figure 3.6):

1. Underwater, fastened a nylon line to the post. The seaweed cuttings are tied to the nylon line at a distance of 8 to 12 inches apart (Figure 3.6B). This procedure is advisable only when the tide is down and the current is not strong.
2. Or, place a nylon line between posts off the water and tie the seaweed cuttings to the line. After completely tying all the seaweed cuttings to the line, place both ends of the nylon line to the opposite posts underwater. This way is good for all

tidal positions except when raining and tying of seedlings are not done under direct sunlight.

3. Or, tie the seaweed cuttings directly to the nylon line near the seedling bed but if there is already a farm house, then do it inside the farmhouse. Then bring the nylon lines to the area and tie the lines to the posts underwater.

During the process of tying, seedlings must be covered from direct sunlight or rain. But it is advisable to submerge them in seawater most of the time. Whenever bamboo-raft is used, follow the same procedure as in the monoline bottom method, except that nylon lines are tied to the bamboo rather than to the posts.

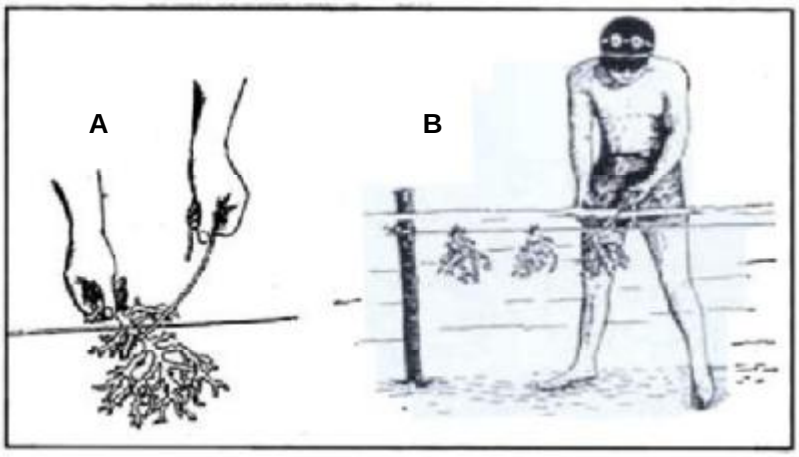


Figure 3.6. Tying of seaweed cuttings to the monoline.
(*adapted from Guererro, 2001*).

3. FARM MANAGEMENT

Assurance for good farm production largely depends upon farm management, procedures and practices coupled with the farmer's own initiative and creativity (Juanich, 1980). According to Hurtado *et al*. (2008), the success of a seaweed farm depends mainly on two critical factors: the **farmer** and the **seaweed**. The **farmer** must do regular visits to the farm site in order to:

- monitor changes or development of the cultured seaweed as well as changes in the environmental condition,

- remove silt and prevent epiphytes and other animals from lodging on the seaweeds by shaking cultivation lines,
- replace missing and slow-growing plants and ,
- prune affected thallus during disease outbreak.

On the other hand, **seaweeds** to be cultured must come from the best quality seed stocks. They should posses the following characteristics:

- heavily pigmented thallus,
- brittle, shiny and slimy branches,
- young branches with sharp pointed tips and
- no traces of grazing or early signs of “ice-ice” and goose bumps

Seedling Selection and Planting

Activity 4

You will be given several seedlings of *Kappaphycus* for planting. You are to evaluate the seedlings based on the description presented on the table below of a good quality seed stock. Please check (/) the items that fit the description of your seedling.

Seedling Selection

Seedling	heavily pigmented thallus	brittle, shiny and slimy branches,	young branches with sharp pointed tips	no traces of grazing or early signs of "ice-ice" and goose bumps
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

After the selection of the best quality seedlings, you are going to conduct an actual planting activity in the field following the procedures introduced in this module. During the actual planting, you will be accompanied by the trainors for field demonstration on the proper way of tying seedlings on the planting lines. If this is not possible, demonstrations will be made to simulate the tying activities done in the field.

Review Questions:

1. List down some important consideration in the process of transporting and selecting good quality seedlings for planting.

   _____

   _____

2. Enumerate the proper farming management procedures that seaweed farmers are required to do during the culture period.

   _____

   _____

Sub-Module 4: Diseases and Control Measures

Overview

Another problem encountered in seaweed farming is the extreme occurrence of epiphytes on the cultured seaweed that contributes to the loss of biomass. Epiphytes are plants that grow on top of or are supported by another plant but do not depend on it for nutrition but will compete for sunlight. They are classified according to their sizes.

Learning Objectives

At the end of this sub-module, the participant will be able to:

- Identify the common problems usually encountered in a seaweed farm.
- Identify seaweeds infected with 'ice-ice" disease and epiphytes.
- Differentiate between macro-epiphytes and meso-epiphytes.
- Identify some macro-epiphytes and meso-epiphytes that usually attack seaweeds farm.
- List down control measures adopted in seaweed farming to minimize or reduce infection of the cultured seaweeds.

Three biological factors that cause tremendous loss of biomass in farms are **"ice-ice"** disease, presence of **epiphytes** and **grazing**.

"Ice-ice" disease is the whitening of the thallus or loss of color caused by unfavorable environmental conditions like; low salinity and low temperature. **"Ice-ice**" could also be described as bacterial or fungal infection that causes the discoloration of the seaweeds.

Figure 4.1. *Kappaphycus* seedling with "ice-ice" disease.

The **meso-epiphytes** are very small (‹ 1mm) and cannot be counted. Those that are easily observed and can be counted are the **macro-epiphytes** (›1mm). Among the common meso-epiphytes are the ***Polysiphonia*** locally known as "balahibo", "bolo", or "bungot-bungot" and the ***Neosiphonia*** which are also called locally as "bulbol amo", "lambog" and "serin serin". These particular epiphytes invade the tissues of the host and grow intercellularly (inside the cells) damaging the cortical and medullary cells. The macroepiphytes that are loosely attached to the surface of the host are; *Ulva, Chaetomorpha Dictyota* and *Hydroclathrus.* Whereas, *Gracillaria, Acanthophora*, and *Chondrophycus* - are those that are strongly attached to the surface of the host. However, both groups show no evidence of tissue damage on the host.

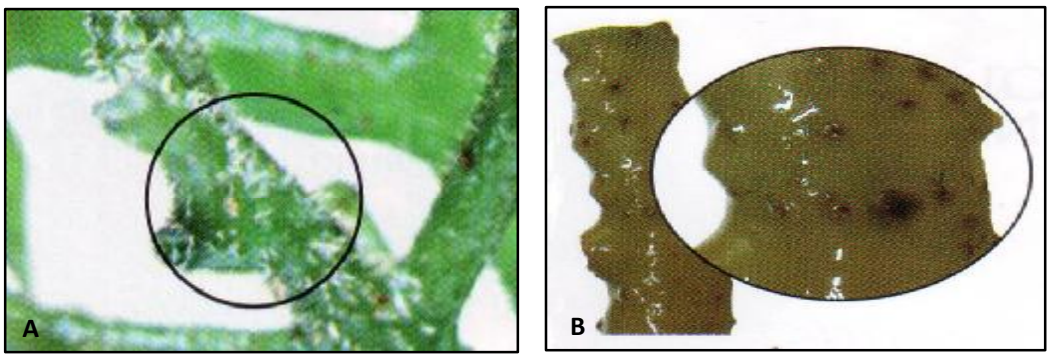


Figure 4.2 . Common Mesoepiphytes observed in seaweed farms (adapted from Hurtado *et al.* 2008). A. Mesoepiphytes infestation on the thallus of *Kappaphycus.* B. "Goose bumps" early infestation of *Polysiphonia* or *Neosiphonia* epiphytes.

Figure 4.3. A green macroepiphyte, *Ulva reticulata*, entangled in a *Kappaphycus* seedling.

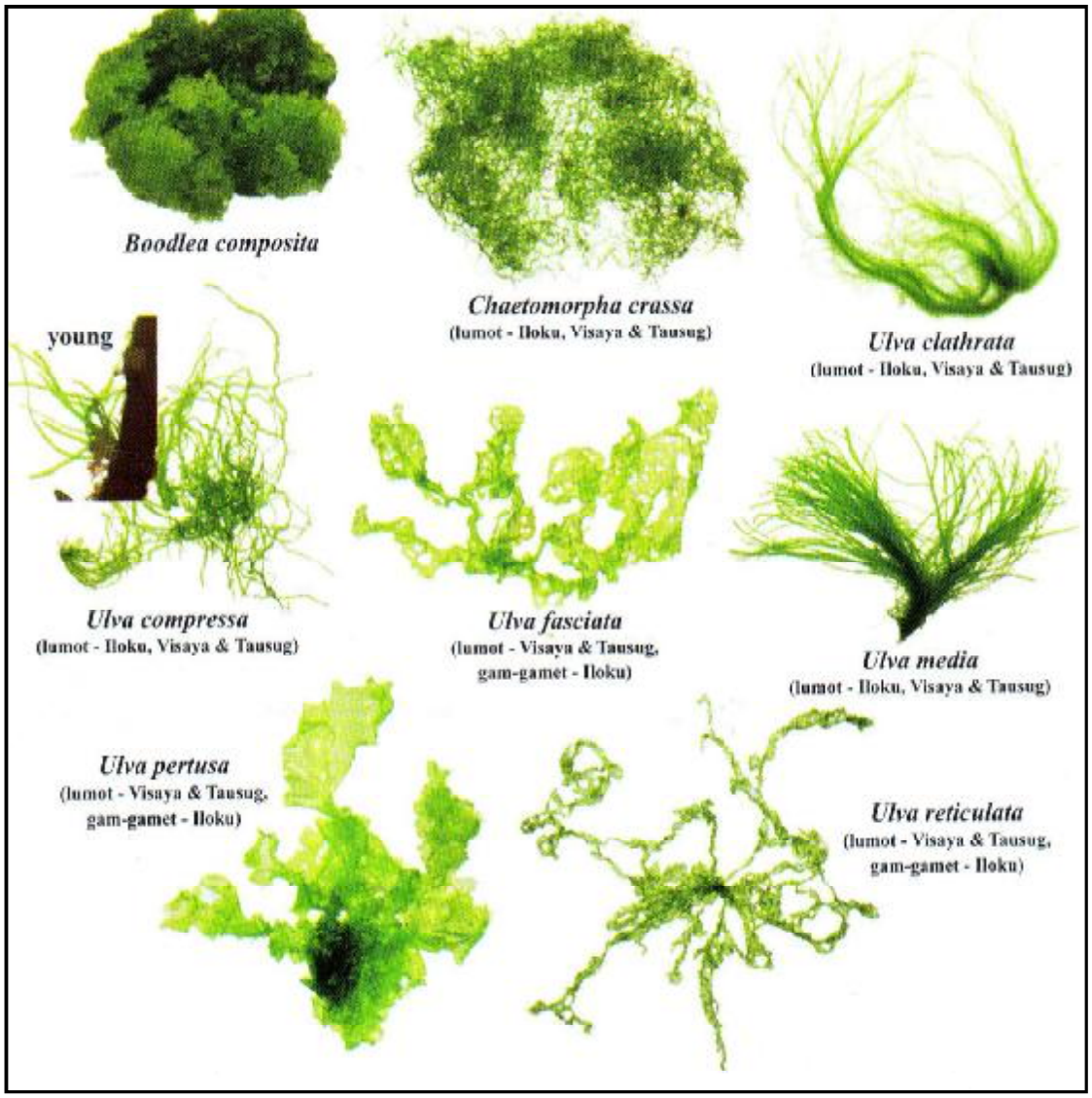


Figure 4.4. Green macroepiphytes common in seaweed farms.

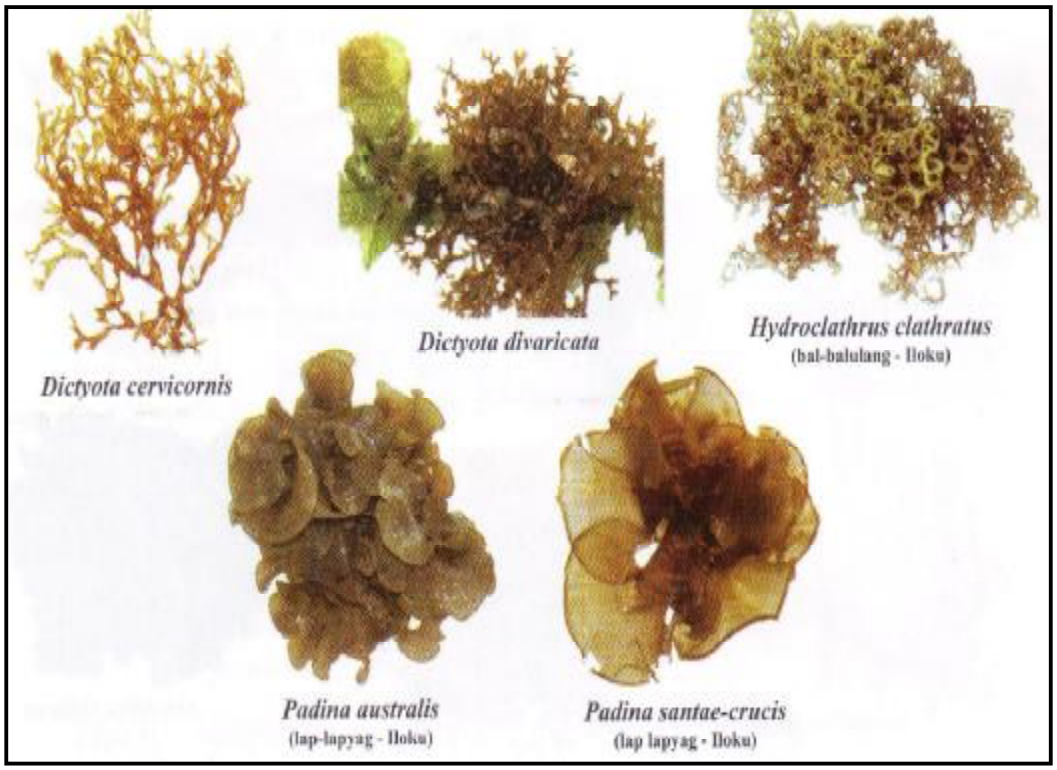


Figure 4.5. Brown macroepiphytes common in seaweed farms.

Figure 4.6. Red macroepiphytes common in seaweed farms.

Table 1. Factors affecting the biomass of seaweeds.

BIOLOGICAL FACTORS	AGENT	TYPE	SYNDROME	MEASURES
Grazing	Herbivores	Fish & invertebrates	Loss of biomass; occurs year-round	Use floating method in deeper areas
Epiphytes	Benthic algae	Filamentous	Epiphytic blooms; occurs in summer	Submerge 1 m below water surface in areas with moderate current
'Ice-ice'	Harsh environmental conditions Microorganisms	Bacteria & fungi	Slow growth rate; pale thalli; loss of shiny branch surfaces; presence of epiphytes & flotsam; occurs in calm weather & summer months	Transfer to areas where water is cool & good current movement

Activity 5

Seaweed Epiphytes

Objectives:

- Identify the common epiphytes that usually attack seaweed farms.
- Classify the epiphytes as to their respective taxonomic group
- Differentiate them as macro-epiphyte and meso-epiphyte

Procedure:

1. You will be provided samples of seaweeds contaminated with various epiphytic algae.
2. Using a knife, isolate the epiphytes on a petri dish and examine them with hand lenses or a stereo microscope.
3. Make sketches of your sample.

Observation:

Drawing	Division (color)	Classification (size)	Common Name

Review Questions:

1. What are the common epiphytes you encounter in your samples?
2. Which of the epiphytes you identify are the most abundant?
3. How will you reduce or minimize the presence of epiphytes in your seaweed farm?

Sub-Module 5: Harvesting and Post Harvest Management

Learning Objectives:

At the end of this sub-module, the participant will be able to:

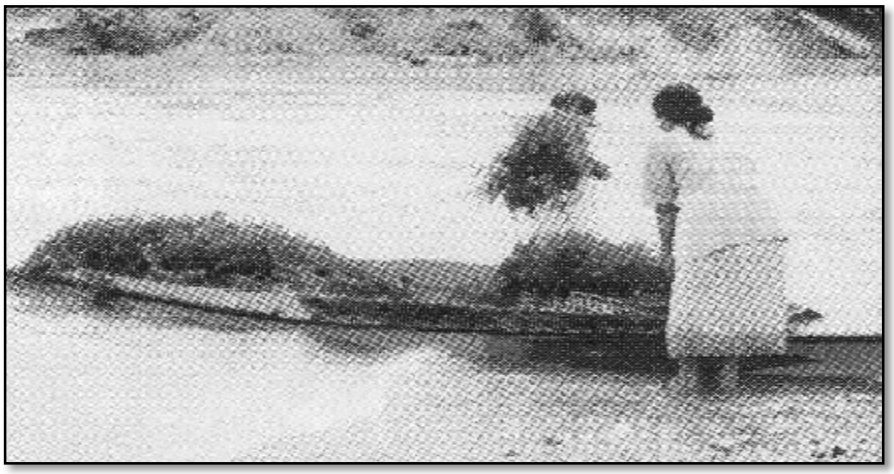
- Describe the harvesting techniques commonly practiced in *Kappaphycus* farm.
- Describe the common practices done on seaweeds before drying.
- Name two methods of drying seaweeds.
- Enumerate the do's and don'ts in drying seaweeds.
- Explain how moisture content of dried seaweeds affects during storage.

1. Harvesting

One production cycle in seaweed farming may last only for two months. Under normal condition, cultured seaweeds are harvested after 45 - 60 days. However, when the farm is highly infested with epiphytes or an "ice-ice" outbreak occurs, seaweeds are harvested after 30 days of planting.

1.1. Basic Ways of Harvesting

- **Multiple raft long-line methods:**



Individual seaweed is untied or cut from the cultivation rope.

- **Fixed off-bottom and hanging long-line:**

Both ends of the cultivation lines are untied from the stakes. Using a line stripper, seaweeds can be remove from the loop and cultivation line leaving the harvest free from the tying material or “tie’tie”.

- **Hanging long line**

The cultivation line is untied from the support line.

2. Post-harvest Management

Post harvest management is an important factor that farmers must take into consideration. This is to ensure that good seaweeds are being produced and best quality is maintained as to command high value in the market. For best quality seaweeds,

cleaning and drying techniques are very important factors that farmers have to put attention. Cleaning is done by removing sediments and other unwanted particles by rinsing the seaweeds several times while still in the sea. Further removal of epiphytes (non-*kappaphycus* seaweeds), other live animals (shells, soft corals, sponges), and tying materials ('tie-tie') is done while on land prior to drying.

Two common methods of drying; ground level and off-ground level drying are the common practice of drying seaweed used by farmers. In the ground level drying (figure 5.1), seaweeds are sun dried using any of the following: fish nets, bamboo mats or even coconut leaves as alternative. The seaweeds must be 3 – 5 cm thick and frequent turning is recommended to accelerate drying. It takes about 4 -5 days for the seaweeds to be dried. Another way of drying seaweeds is the off-ground drying. In this method, platform and hanging lines are used to allow air to circulate thus accelerates the drying process of the seaweeds (figure 5.2). This particular method requires capital for the construction of the platform. However, it has an advantage over the ground level drying method because drying period is shortened to 2 -3 days. The use of solar tunnel dryer may be recommended to reduce considerably drying time and increase seaweeds quality and hygienic conditions.

Figure 5.1. Ground level drying using fishnets

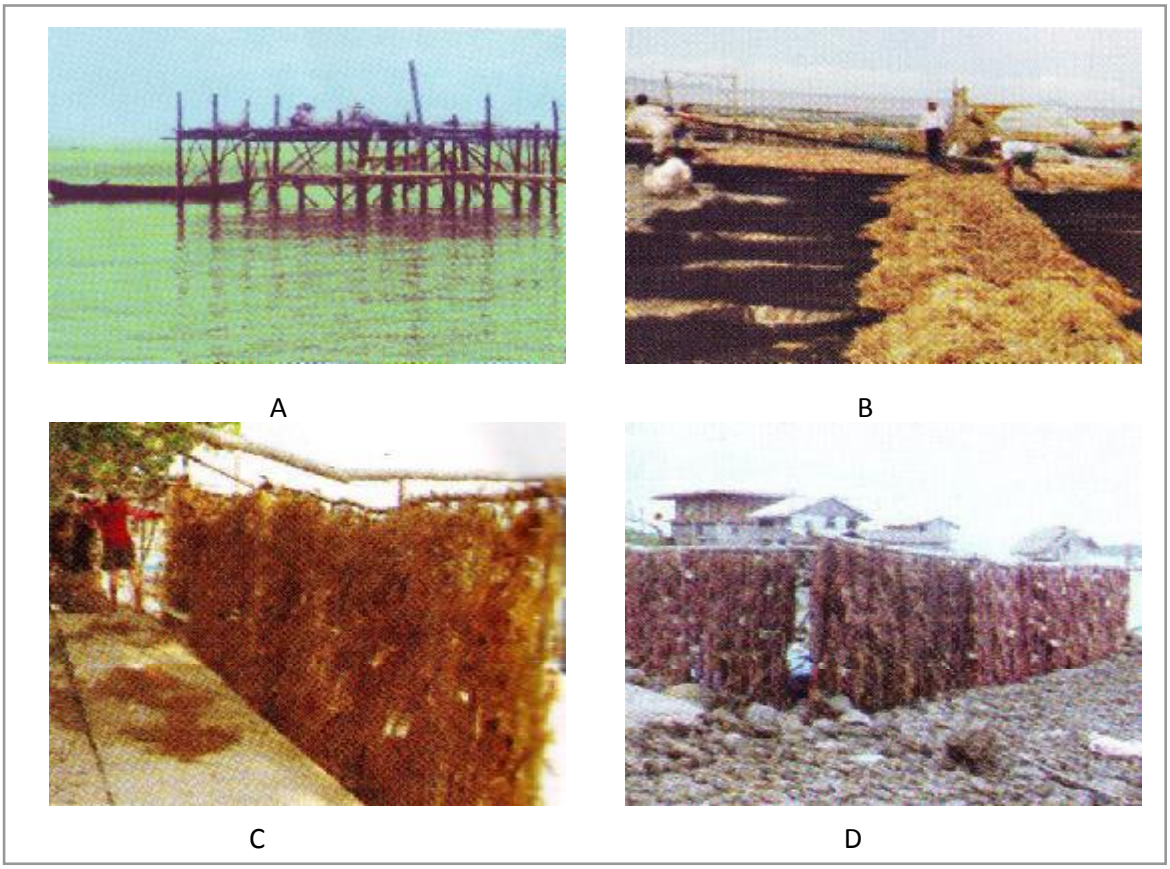


Figure 5.2. Off-ground level drying: (A &B) Platform Drying, (C& D) Hanging Line Drying

Another consideration is the moisture content of the dried seaweeds. This is very critical because it dictates the market price of seaweeds. The recommended moisture content is about 35% upon storage. Seaweed condition in this level of moisture content is very stable. Seaweeds may undergo degradation at higher moisture content during storage while lower moisture content may give more stability for longer storage. However, seaweeds may become too brittle; resists pressure or snaps during baling and cause processing problem. Dried seaweeds must be stored for the shortest possible time in clean, cool, dry and well-ventilated place. Never store wet seaweed especially in piles; unbaled seaweed usually picks up moisture – rehydrates from the moisture in the air (table 2).

Table 2. Percentage Moisture contents of dried seaweeds with its corresponding condition

MOISTURE CONTENT (%)	SEAWEED CONDITION
› 40	Undergoes degradation
35	Most stable
25 – 35	Relatively stable for periods in excess of 12 months (efficient for baling)
15 – 25	Extremely stable, but seaweed maybe too brittle; resists pressure or snaps during baling
‹ 15	Stable, but can cause processing problem

.

Moisture Content Determination of Dried Seaweeds

Activity 6

Objectives:

- Determine the moisture content of dried seaweeds
- Determine drying time of the required moisture content of dried seaweeds for storage.

Procedure:

1. Using an Infrared moisture balance, determine the moisture content of dried seaweeds at different drying time.

Note: You have to record the air temperature during drying.

Observation:

Drying Time	Moisture Content	Remark (condition)
12 hours (1 day)		
24 hours (2 days)		
36 hours (3 days)		
48 hours (4 days)		
50 hours (5 days)		

Review Question:

1. How does drying time affects the moisture content of the seaweed?

2. What other factors you are to consider during drying of seaweed?

Sub-Module 6: Acquisition of Permit to Farm

The proposed area you are applying for seaweed farming purposes must be surveyed by a geodetic engineer. This is to determine the area's bearings and the exact size including the total area in square meters intended for your farm. After the location and bearing had been determined, as an applicant you should get and fill up the official application form from the Bureau of Fisheries and Aquatic Resources (BFAR). Upon advise from the BFAR office you can then prepare all the necessary requirements as provided for by law. Guidelines promulgated by the (BFAR) must be followed to the fullest to avoid cancellation of the application (**Appendix I**). It should be noted that the application should be approved first before a permit is issued and before commercial farming commences.

Evaluation

Answer the following questions.

Direction: Place a check (√) next to the letter of your answer/s in the following items below:

1. Which of the following best describe the term seaweed?

- ☐ a. plants growing in shallow areas of the ocean
- ☐ b. simple plants without true roots, stem and leaves
- ☐ c. have flowers and fruits
- ☐ d. absorbs nutrient from the surrounding water

2. Seaweeds containing the red pigment are classified as:

- ☐ a. Chlorophyta
- ☐ b. Phaeophyta
- ☐ c. Rhodophyta
- ☐ d. Cyanophyta

3. Seaweed farming is a way of cultivating seaweed in specified areas by any method with an appropriate intensive care for commercial production.

- ☐ a. TRUE
- ☐ b. FALSE

4. The most important factors in selecting a good site for seaweed farm are:

- ☐ a. Farm area with moderate water current.
- ☐ b. Water temperature ranges from 25 ^{0}C to 40 ^{0}C.
- ☐ c. Salinity range from 30 to 35 ppt.
- ☐ d. Protected from large waves and strong winds.

5. Seaweeds farming could be a viable alternative livelihood for coastal community because of:

☐ a. Supervision is not required.

☐ b. Culture period is short as 45 days under optimal conditions.

☐ c. High return on investment.

☐ d. Demand for seaweeds is high in local and international markets.

6. Which of the following statement is ***not*** an ecological importance of seaweed?

☐ a. Seaweeds serve as food for various marine organisms.

☐ b. Seaweeds provide shelter and habitat for fish and other invertebrate animals.

☐ c. Seaweeds are used as medicine.

☐ d. Seaweeds are sources of phycocolloid substances.

7. **Salinity** is defined as "the amount of solid materials in grams contained in one ton of seawater.

☐ a. TRUE

☐ b. FALSE

8. Which of the following are the **biological factors** that influence a seaweed farm?

☐ a. Grazers

☐ b. Salinity

☐ c. Epiphytes

☐ d. Water temperature

9. Environmental factors that seaweed farmers must take into consideration are:

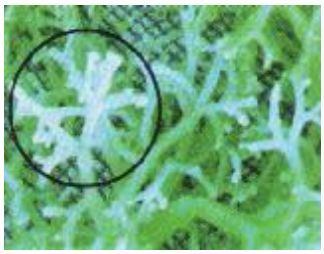
☐ a. Moisture content of dried seaweeds.

☐ b. Growth rate of the cultured seaweeds.

☐ c. Diseases of the seaweeds.

☐ d. Physical and chemical condition of the water.

10. The illustration depicts a disease in seaweeds known as:



☐ a. Predation

☐ b. Epiphytism

☐ c. “Goose bumps”

☐ d. “Ice-ice”

11. Among the common red macro-epiphytes, identify those listed below>

☐ a. *Actinotrichia fragilis*

☐ b. *Hypnea musciformis*

☐ c. *Ulva lactuca*

☐ d. *Padina australis*

12. Which farming technique uses monofilament lines to culture seaweeds?

☐ a. Fix off-bottom method

☐ b. Spider web method

☐ c. Floating raft method

☐ d. Multiple floating long-line method

13. The floating monoline method has an advantage over the fix-off bottom method for several reasons;

☐ a. Plants are exposed to more moderate water movement.

☐ b. Plants are exposed to direct sunlight.

☐ c. Plants are protected from epiphytes.

☐ d. Plants are protected from grazers.

13. If the cultured seaweed is infested with epiphytes, the farmer should:

- ☐ a. Submerge the plants 1 m below water surface in areas with moderate current.
- ☐ b. Transfer the plants to areas with cool water and good current movement
- ☐ c. Remove all the plants that are affected.
- ☐ d. Use the floating method in deeper areas.

14. The success of a seaweed farm depends mainly on **two** critical factors: the _____ and the _____.

- ☐ a. farmer, seaweed
- ☐ b. farm site, farmer
- ☐ c. farm site, seaweed
- ☐ d. seaweed, culture technique

15. The **farmer** should regularly visit the farm in order to:

- ☐ a. Monitor changes or development of the cultured seaweed
- ☐ b. Harvest the full grown plants.
- ☐ c. Replace missing and slow-growing plants.
- ☐ d. Remove silt and prevent epiphytes and other animals from lodging on the seaweeds.

16. A good quality seed stock for planting must be:

- ☐ a. Young branches with sharp pointed tips
- ☐ b. Brittle, shiny and slimy branches
- ☐ c. Mature and sturdy branches
- ☐ d. Heavily pigmented thallus

17. Which of the following a farmer must observed during harvest and post-harvest in order to maintain the quality of dried seaweeds?

- ☐ a. Wash the seaweeds and remove the sediments while still in the sea.
- ☐ b. Wash and clean seaweeds with freshwater.
- ☐ c. Add salt to seaweeds during drying to increase storage time.
- ☐ d. Dry immediately after cleaning and sorting.

19. In the multiple raft long-line method, the common practiced used by farmers in harvesting seaweeds is;

- ☐ a. The cultivation line is untied from the support line.
- ☐ b. Individual seaweed is untied or cut from the cultivation rope.
- ☐ c. Individual seaweed is pruned leaving a portion to grow again.
- ☐ d. Both ends of the cultivation lines are untied from the stakes.

20. The most appropriate moisture content of dried seaweeds for storage is;

- ☐ a. below 15 %
- ☐ b. 25 – 35 %
- ☐ c. 25 – 40 %
- ☐ d. 15 – 25 %

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Appendix A

ACQUISITION OF PERMIT TO FARM

Republic of the Philippines
Ministry of Natural Resources
Diliman, Quezon City

FISHERIES ADMINISTRATIVE)
ORDER No. 146 :
Series of 1983.)

SUBJECT: Rules and regulations governing the gathering and farming of seaweeds.

Pursuant to Sections 4 and 7 of Presidential Decree No. 704, otherwise known as the "Fisheries Decree of 1975", and the provisions of Batas Pambansa Bldg. 325, the following rules and regulations governing the gathering and farming of seaweeds are hereby promulgated:

Section 1. Definition of terms and phrases - For purposes of this Order, the following terms and phrases as used herein shall mean as follows:

Seaweeds - All marine algae used as food or producing derivatives such as agar, agrums, algin, carrageenin, or other extracts of economic or commercial value, such as but not limited to.gulaman dagat (tagalog), lato (Visayan), gozo, (Visayan), and garnet (Ilocano).

Seaweed farming or culturing - The cultivation of any seaweed in authorized specified areas by any method with appropriate intensive care for production in commercial quantities.

Seaweed farm lot - An authorized specified area for the farming culture of seaweeds.

Seaweed farmer - Any person, natural or juridical, engaged in the farming or culture of seaweeds.

Seaweed actual gatherer - Any natural person taking or gathering seaweeds from the natural or wild growth in areas other than seaweed farm lots.

Actual seaweed gathering - The taking or removing of any seaweed from the natural or wild growth in areas other than seaweed farm lots.

Scientific, research, and/or educational purposes - Seaweed gathering or farming shall be deemed for scientific, research, and/or educational purposes whenever, to the exclusion of gain, its purpose is the study of or experimentation with seaweeds.

Permit to gather - Permit issued to a seaweed actual gatherer for the taking or gathering of seaweeds from the natural or wildgrowth In areas designated by the Director u seaweed restricted area.

License to culture - License Issued for seaweed farming or culture with a definite area of coverage.

Gratuitous permit - Permit issued to gather seaweed In areas designated by the Director as seaweed restricted areas or to culture seaweeds for scientific, research, and/or educational purposes.

Seaweed restricted area A seaweed resource area so designated by the Director where free gathering of seaweeds is prohibited.

Director - The Director of Fisheries and Aquatic Resources.

Minister - The Minister of Natural Resources.

Section 2. Gathering and/or culture of seaweeds. - No person, partnership, association, corporation, cooperative shall gather seaweed in areas designated by the Director as seaweed restricted areas and seaweed farm lots or culture seaweed in any public water area in the Philippines without any of the following permits or license issued by the Director:

a) Permit to Gather
b) License to Culture
c) Gratuitous Permit.

Section 3. Who are entitled to gather and/or culture seaweeds. **–**

A. Citizens of the Philippines;
B. Partnerships, associations, or corporation duly registered in accordance with law and at least sixty (60%) percentum of the authorized capital stock of which belongs to citizens of the Philippines;
C. Cooperatives duly registered in accordance with law.

Section 4. Restrictions on seaweed fanning or culture.-

1. *Size of seaweed farm lot* **–**

a) For individual - Not more than an aggregate maximum area of 1 ha. provided that only one license shall be issued to a family, either to the husband or the wife, unless they are living separately and independently from each other, and provided further that any member of the family and living independently, may also apply for a license.
b) For partnership, associations, corporations, or cooperatives -Not more than an aggregate maximum area of 30 has.
c) The provisions of the preceding paragraphs (a) and (b) notwithstanding, the Minister may, upon the recommendation of the Director, increase or decrease the area that may be granted for reason of public interest, taking into consideration (1) the financial capacity and/or qualification of the applicant; (2) the socioeconomic importance of the project or industry for which the area is applied and (3) the existence of numerous applications for permit and/or license in the place where the area applied for is located.

2. *Establishment of seaweed farm lot* - No seaweed farm lot shall be established within a distance of sixty (60) meters from another nor shall they be so established as to obstruct free navigation.

Section 5. Restrictions on seaweed gathering. - No person shall gather, take, or remove seaweed from any farm lot area covered by an existing license to culture except the licensee thereof, nor shall any person gather, take or remove seaweed from any seaweed restricted area without a permit to gather or a gratuitous permit issued by the Director.

Section 6. Fees. - The following fees shall be collected when applicable:

a) Application fee to gather - P2.00
b) Application fee to culture - P20.00

c) Permit fee to gather - P2.00
d) License fee to culture - P50.00 per 10,000 square meters or fraction thereof

Section 7. Obligations of seaweed gatherers, when applicable

a) Record of seaweed gathered under the permit - A permittee shall submit to the Director a monthly statement of seaweeds gathered on a prescribed form;

b) A permit to gather shall be carried at all times and shall be presented upon demand by any inspecting fishery officer.

Section 8. Obligations of seaweed farmer-licensee -

a) The seaweed farmer-licensee shall comply with all pertinent existing laws, rules and regulations, and those which may hereinafter be promulgated;

b) He shall assume responsibility for any and all acts of his agents, employees, or laborers in the establishment, management or operation of the seaweed farm lots;

c) A holder of license to culture seaweeds shall keep a book a books to record all kinds of seaweed cultured and harvested from the farm lot under license, indicating therein the date of planting, the kind, quantity, date of harvest and the capital invested. The book or books shall be numbered consecutively and shall be subject to inspection and verification by the Director or his duly authorized representative. The farmer-licensee shall also submit a monthly statement of all seaweeds cultured and harvested to the Director in a prescribed form.

d) When applicable in the event of foreclosure, the mortgage-bank shall have a period of five (5) years thereafter to hold the area covered by the license for the purpose of liquidating the mortgage debt, disposing of the improvements therein, and negotiating for the transfer or assignment of the rights therein to other qualified transferees or assignees who shall comply with the requirements of this Order.

Section 9. Duration of the license. - A license to culture seaweeds in any public water area of the Philippines issued by the Director shall be or a period of not exceeding ten (10) years subject to renewal: a permit to gather shall be for a period of one (1) year subject to renewal; and a gratuitous permit shall be for a period of six (6) months subject to renewal.

Section 10. Grounds for rejection of application, suspension or cancellation of gratuitous permit, permit to gather and license to culture seaweeds. –

1. An application to gather and/or culture seaweeds shall be rejected under the following grounds;

a) Giving false statements in the applications;

b) Unsuitability and non-availability of the area applied for.

2. A gratuitous permit, a permit to gather, and/or license to culture seaweeds shall be suspended and/or cancelled on the following grounds:

a) Non-use of the license to culture within one (1) year from the date of issuance;

b) Violation of existing fishery laws, rules and regulations and the terms and conditions of the permit;

3. The Director may at any time reduce or alter the area covered by the license to culture or change or modify the terms and conditions of the license or permit, or the same may be made to expire at an earlier date when public interest so require or for justifiable grounds or reasons, among which are the violations of the conditions of the license or permit and pertinent rules and regulations.

4. Any or all fixed improvements of the farm lot shall be removed the licensee therefrom within sixty (60) days from the date of cancellation or termination of the license.

Section 11. Penal Provision. - Any violation of this Order shall subject the offender to a fine of from five hundred (P500.00) pesos to five thousand (P5,000.00) pesos, or imprisonment from six (6) months to four (4) years , or both such fine and imprisonment, in the discretion of the Court: *Provided*, That the Director is hereby empowered to impose upon the offender an administrative fine of not more than five thousand (P5,000.00) pesos or to cancel his permit or license, when applicable.

Section 12. Repealing Clause. - All existing administrative orders, rules and regulations or parts thereof which are inconsistent with the provisions of this Order are hereby repealed or amended accordingly.

Section 13. Effectivity. - This Order shall take effect fifteen (15) days after its first publication in the Official Gazette and/or in two (2) newspapers of general circulation and the increase in the application fee shall take effect fifteen (15) days after its last publication in two (2) newspapers of general circulation for two (2) consecutive weeks.

(SGD.) **TEODORO Q. PENA**
Minister
Ministry of Natural Resources

RECOMMENDED BY:

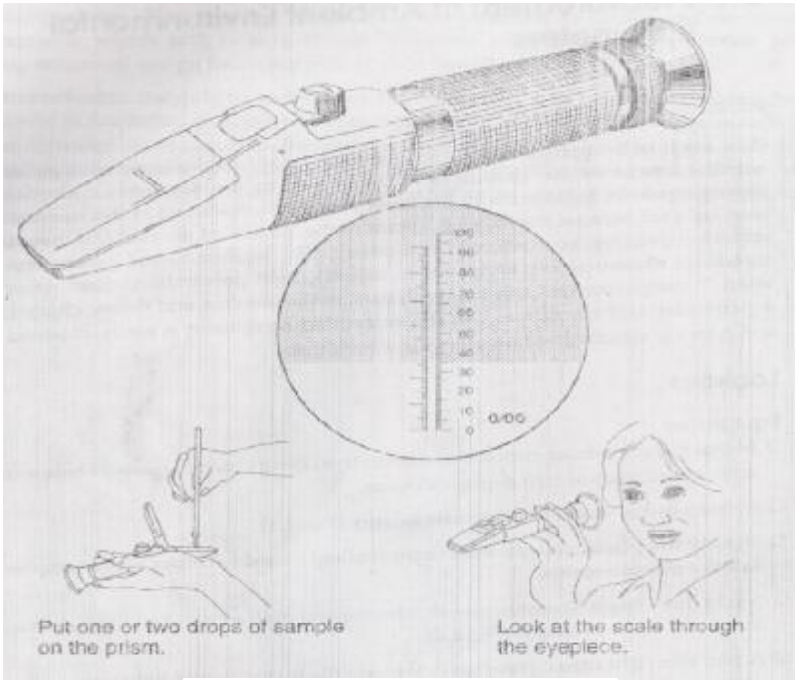
(SGD.) **FELIX R. GONZALES**
Director
Bureau of Fisheries and Aquatic Resources

APPENDIX B

Methods of Measuring Seawater Parameters

Salinity

Generally, salinity of coastal waters varies little, but in estuaries it varies considerably. The simplest method in determining salinity is the use of a refractometer (Fig. A.1).



The refractometer and its use.

Light (Visibility/Transparency of Seawater)

A commonly employed method of estimating the depth of light penetration into a body of water is the Secchi disk (Fig. A.2), which is easily constructed.

1. Take a firm metal disk (or plywood) about 8 inches in diameter and paint it with several coats of while enamel. Divide the disk into quadrants and paint the alternate sectors black.

2. Attach the disk by the center to a rod cord (rope) calibrated for depth. Be sure the disk is fitted to ride level when it is lowered into the water (Fig. A.2).

3. Lower the disk over the side of the boat and note the depth at which the disk disappears. Sink the disk several more feet , then raise it, noting the depth at which the disk disappears.

4. Average the two observations to obtain a single water transparency reading.

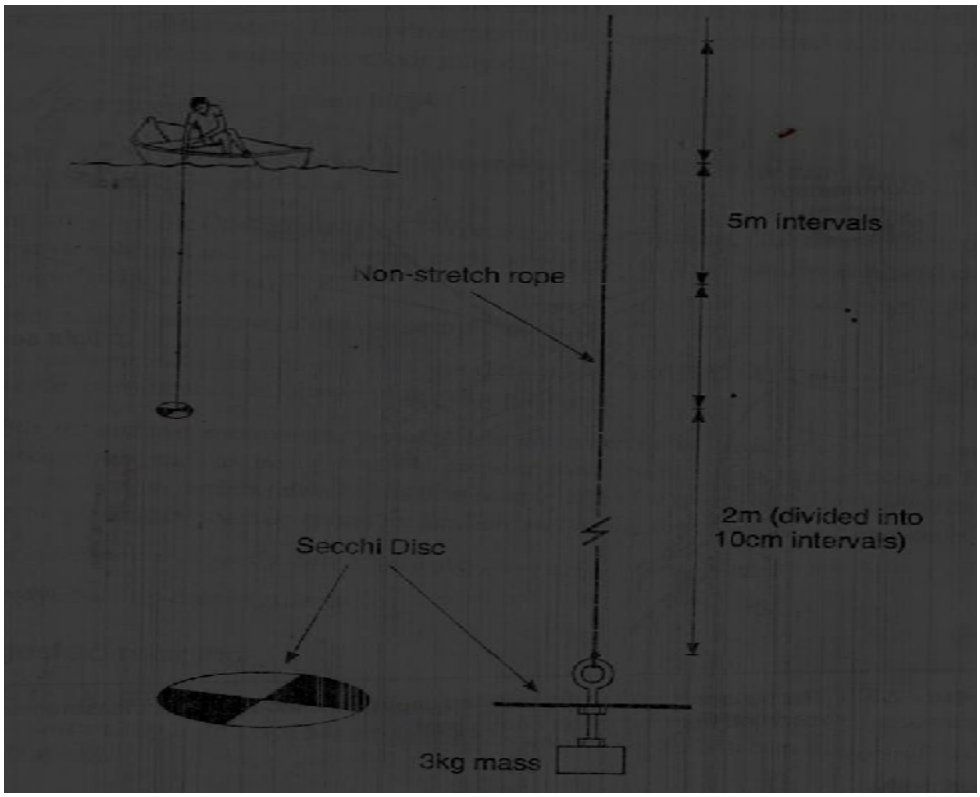


Figure A.2. The Secchi disc and its use.

Water Current

A drift device called drogue is commonly used to trace the path of the current flow (Fig A.3). Drogues are categorized as a float method of current measurement (McCormick and Thiruvathukal, 1981).

1. Release the drogue in the water and let it drift for 30 minutes to 1 hour. Note the distance traveled.

2. Calculate the velocity/speed of current using the following formula:

Velocity = distance travelled in m / time covered in minutes

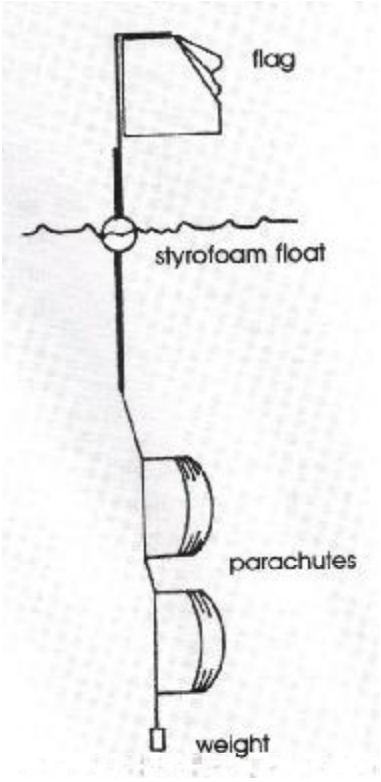


Figure A.3. The drogue design.