EXTENSION MANUAL NO. 32 SEPTEMBER 2000

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Foreword

Kappaphycus, a red seaweed locally known as ‘guso’ or ‘tambalang,’ constitutes eighty percent of the Philippines’ seaweed export. It is also one of the top three marine-based export of the country. As an aquaculture enterprise, seaweed farming has been proven to be a top foreign exchange earner. Likewise, it can provide alternative livelihood for our coastal farmers, particularly in southern Mindanao.

Worldwide, the Philippines ranks fourth in seaweed production behind China, South Korea, and Japan in 1995. North Korea and Indonesia were ranked fifth and sixth respectively. Small-scale farming of *Eucheuma* exists in Malaysia, likewise *Gracilaria* farming in Thailand.

The three main processed seaweed products marketed in Indonesia, Thailand, Malaysia and the Philippines are agar, alginate and carrageenan. Indonesia will most likely focus its attention as an alginate producer because of its fairly large local market. Malaysia and Thailand are foreseen to continue importing the phycocolloids due to lack of large-scale farming areas. The Philippines, having a well-established carrageenan industry is expected to maintain, if not increase, its output in coming years.

We hope this manual will prove useful to new entrepreneurs, extensionists and students of tropical aquaculture in Asia, Africa and Latin America.

Rolando R. Platon, Ph.D.
Chief, SEAFDEC Aquaculture Department

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The farming of the seaweed *Kappaphycus*

Introduction

HISTORICAL DEVELOPMENT

The gathering of the seaweed *Kappaphycus* (originally called *Eucheuma*) from wild population for export purposes started in the late ’50s and early ’60s. This seaweed grew abundantly in the shallow waters of Jolo, Tawi-Tawi, Cebu and Bohol. The demand from North American and European processing plants at that time was so high that seaweed harvesting became uncontrollable. As a result, this marine resource became depleted.

The above situation led to the pioneering efforts of the late Dr. Maxwell S. Doty of the University of Hawaii and Mr. Vicente B. Alvarez – both are known as the fathers of *Eucheuma* farming in the Philippines – and Dr. Gavino C. Trono, Jr. of the University of the Philippines (UP). They studied the biology and ecology of this seaweed and developed its culture techniques. Between 1969-1970, there was a massive search for the ideal site of farming *Kappaphycus* as a result of the rejection of Indonesian carrageenan by American markets because of political problems. The loss of Indonesia was the gain of the Philippines. The search was initiated by the US-based FMC Marine Colloids Division in cooperation with the Bureau of Fisheries and Aquatic Resources and the UP–Marine Science Institute. Their persevering efforts were not wasted as the first commercial plantation was established in Tapaan Island, Siasi, Jolo in 1973.

Since then, extensive farming has become the major livelihood among seafarmers in southern Mindanao particularly the Sulu archipelago. Today, it has expanded to other parts of the country like the Visayas and Luzon (Fig. 1) and to other countries like Micronesia, Fiji, East Africa and China.

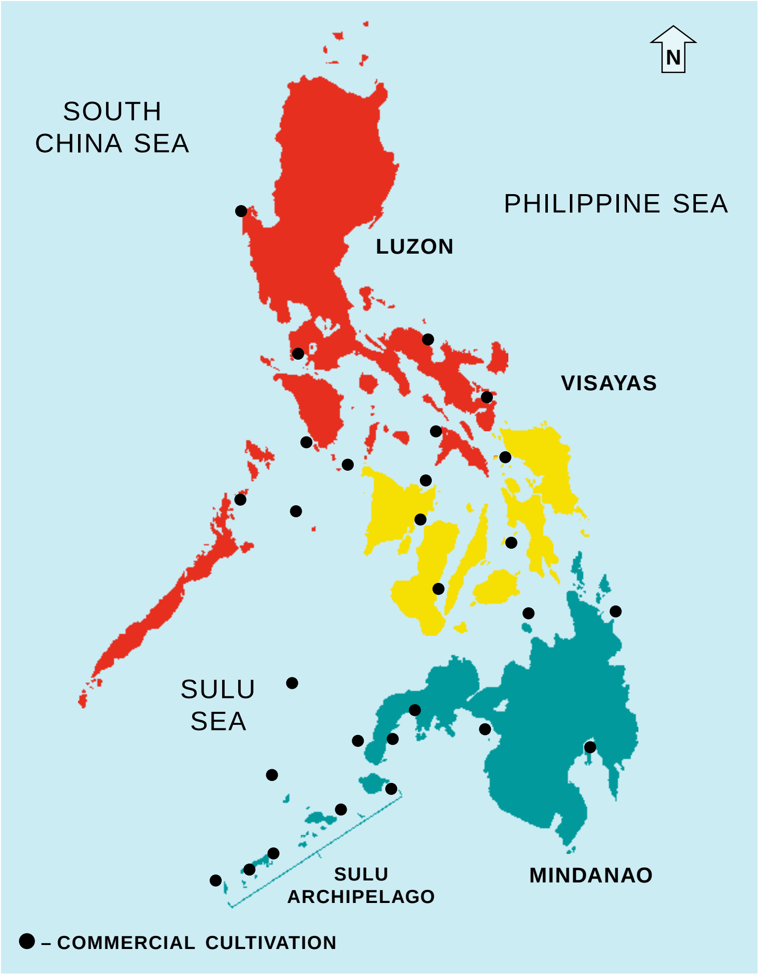


Figure 1. Production areas in the Philippines

MARKETING

Kappaphycus and *Eucheuma* are sold in fresh and dry forms, however, dried seaweed has a far greater demand in the local and international markets while the fresh seaweed is highly-priced as sea vegetable in restaurants.

Since *Kappaphycus* and *Eucheuma* are farmed in far-flung islands where hauling of dried seaweed by the farmers is a major constraint, seaweed trading is a common practice in these areas. Traders usually visit the farmers after the first harvest and continue to purchase dried seaweed until their quotas with the exporter or processor are met. However, this practice by the traders is not beneficial to the farmers because this leads to oversupply at the end of the culture period and the farmers are forced to sell their products at a lower price. Nevertheless, seafarmers are patient enough to ride out the constant rise and fall in farmgate prices. Without this patience, the seaweed industry would not have grown to today's level.

The presence of a farm house near the plantation area provides shelter to the families of seaweed planters and space for tying seedlings, drying of harvested crops, and selling of dried seaweed. This is a big advantage to farmers. Direct selling of either fresh or dried seaweed to the exporter or processor is done in the farm house.

PROCESSING

There are 24 large processors of carrageenan and less than 10 small factories present in the world market. These are found in: Europe (37%), Americas (23%) and the Asia-Pacific (40%). The process of producing refined carrageenan is either thru alcohol (47%) or gel process (35%) while semi-refined carrageenan is processed thru alkali treatment (18%). Europe and the Asia-Pacific produce both the refined and semi-refined carrageenan.

PRODUCT APPLICATION

Carrageenan is a natural product extracted from *Kappaphycus*. It has a wide range of uses because of its suspending, thickening and gelling properties. Carrageenan is used in:

Meat preparation and processing – where it has the following functions:

- regulates and controls moisture loss during curing of ham and other meat products; improves meat texture and sliceability; tenderizes meat products, and helps retain flavor
- enhances the plumpness and significantly improves freeze-thaw stability of frozen meat like chicken nuggets and frankfurters
- binds meat particles and retains moisture essential to preserving the juiciness and mouthfeel of hamburger patties; serves as a fat substitute
- increases shelf life; will not impart off-flavour and there is no masking of flavours
- prevents shriveling and shrinkage of processed poultry products

Dairy products and desserts

- promotes the smooth and thorough dispersion of reconstituted products, dietetic formulations and other frozen foods
- boosts the solubility and stability of coffee whiteners
- improves the creaminess, texture and consistency of ice cream and related products
- adds richness, body and mouthfeel to powder mix desserts, jams, chocolate milk, dairy desserts and sterilized cream

Beverages and juices

- eliminates beer clouding resulting in a sparkling, clear beer
- improves filterability, taste and chill stability
- adds viscosity and helps stabilize pulp suspension in fruit juices leading to a better appearance, palatability and quality
- provides homogeneous consistency along with improved flowability and prolonged shelf life in instant drink mixes

Cosmetics and personal care products

- ensures excellent stability of toothpaste under conditions of wide temperature variations; enhances shape retention, retains moisture and provides a smooth and even consistency to toothpaste
- gives body to hair gels and reinforces its holding effect
- produces a uniform, homogeneous suspension in lotions, creams and shampoos, thus enriches the texture, stability and overall efficacy of these products

Petfoods

- binds water, provides structure, and prevents fat separation during processing
- imparts a desirable can filling viscosity
- maintains uniform moisture throughout the can
- facilitates easy unmolding from the can
- provides an excellent sheen to the product
- reduces syneresis of food products
- capable of withstanding retorting

Air freshener gels

- provides structure and controlled release of active ingredients such as perfume in a water gel base

Sauces and salad dressings

- prevents water separation
- softens harsh spice flavor
- provides consistency
- prevents sedimentation of solid particles in a suspension

Bread, noodles and pasta

- forms gel matrix during cooking cycle, thus binding moisture and providing additional structure
- improves the resistance of noodles and pasta to breakdown during cooking
- increases water binding capacity of wet noodles, resulting in weight increase
- increases rate of extrusion
- gives the product a superior polished surface

Brief description of *Kappaphycus alvarezii*

There are three forms of *Kappaphycus* that are commercially farmed (Fig. 2a). This seaweed is variable in habit. It may be tall and loosely branched with few blunt or pointed determinate branchlets with a cylindrical axis. Branchlets are irregularly arranged and do not form whorls as in *Eucheuma denticulatum* (Fig. 2b).

Kappaphycus grows in reef flats with coarse sandy-corally substratum exposed to moderate water movement in the tropical intertidal and subtidal waters.

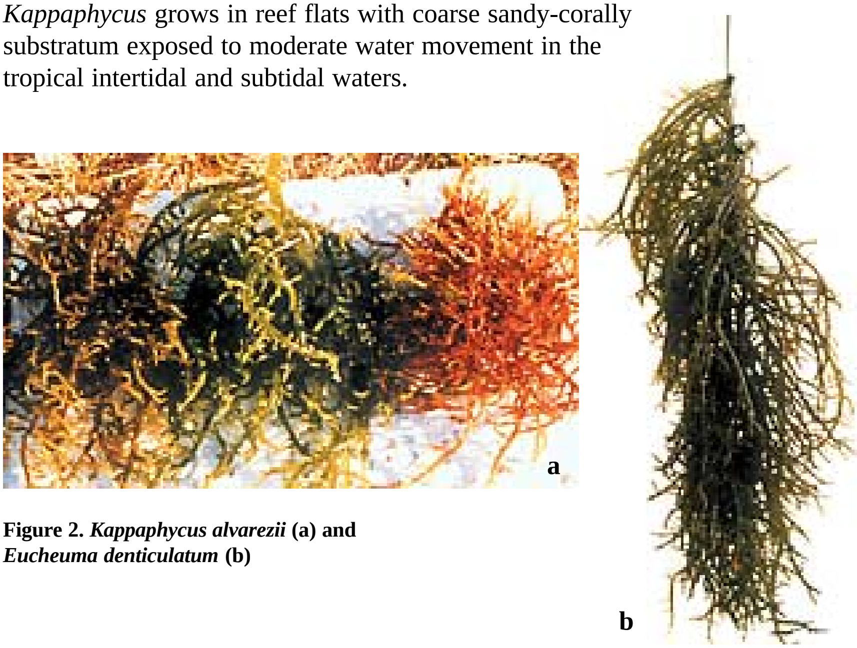


Figure 2. ***Kappaphycus alvarezii*** **(a) and** ***Eucheuma denticulatum*** **(b)**

Culture of *Kappaphycus*

PHYSICAL DETERMINANTS IN SEAWEED PRODUCTION

Site fertility (Doty 1986) – light, water quality, water motion, and water temperature are important environmental factors that determine the fertility of a site. The interaction of these environmental factors are critical during the initial stage of farming (Fig. 3). It dictates success or failure.

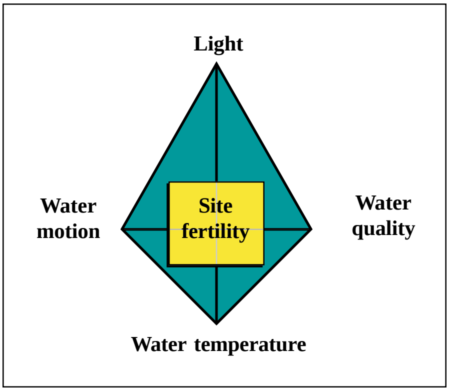


Figure 3. The interaction of environmental factors to site fertility.

Production – as farming progresses, water motion is the most critical factor that determines biomass production and consequently the sustainability of seaweed culture operations.

BIOLOGICAL DETERMINANTS IN SITE SELECTION

Biological factors such as pests and diseases can determine success or failure of the seaweed enterprise. Control or elimination of undesirable seaweeds (epiphytes) and diseases is important to maintain the sustainability of the crop.

Thallus color and growth rates are often indicative of the health of the plant. Below are the most commonly encountered thallus conditions that every seafarmer should be aware of:

- **'ice-ice'** –most common symptom of malaise, but often referred to as a disease; this term applies to the white segments that appear between branches usually in the more basal parts of the thalli; it is a phenomenon caused by low salinity, temperature and light intensity. When the plant is under stress, it exudes an organic substance that is muscilaginous in nature, and the presence of opportunistic bacteria in the water column aggravates the whitening of the branches.
- **'pitting'** – usually occurs at the cortical layer wherein a cavity is formed mainly due to mechanical wound, however, the cortical layer is regenerative

- **'tip darkening'** – this is due to senescence (old age) and cold water which result to loss of color and consequently disintegration, however, seaweed 'tips' can grow back
- **'tip discoloration'** – is due to aerial exposure and intolerance to warm water; there is a change toward pinkness and eventual softening of the tips, followed by further discoloration, finally becoming white, and later dissolving away
- **'slowing of growth'** – this is mainly due to (1) appearance of epiphytes, (2) pigment loss, (3) tissue softening, (4) general decay, (5) poor season, and (6) poor site
- **'die-off'** – is initially manifested by discoloration which is mainly brought by pools of freshwater run-off

Reduction by grazers

Grazing in seaweed farms can be so devastating that it can wipe out a whole plantation. Grazers come in two forms:

Micrograzers are animals less than 2 cm long which take up residence on the thallus and consume the thallus materials (e.g. nematodes and the planktonic stage of echinoderms)

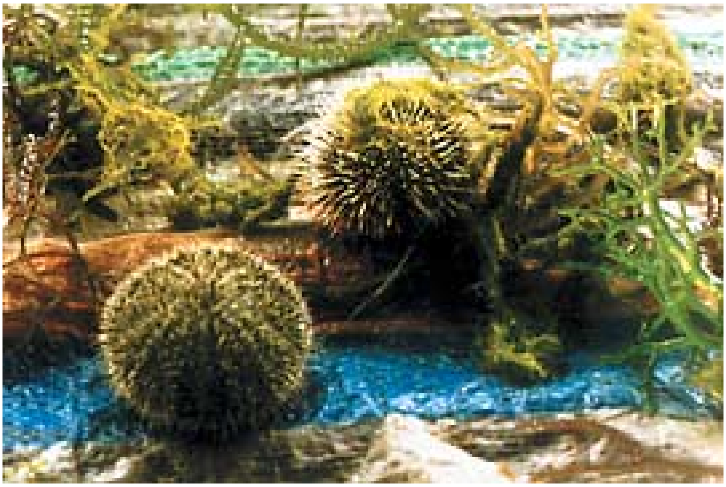


Figure 4. A macrograzer: the sea urchin *Tripneustes*

Sea urchin *(Tripneustes)* (Fig. 4) and synaptid *(Ophiodesma)* settle on the seaweed in planktonic form. As the sea urchin grows and becomes visible, it grazes on the thallus, leaving a hollow at the

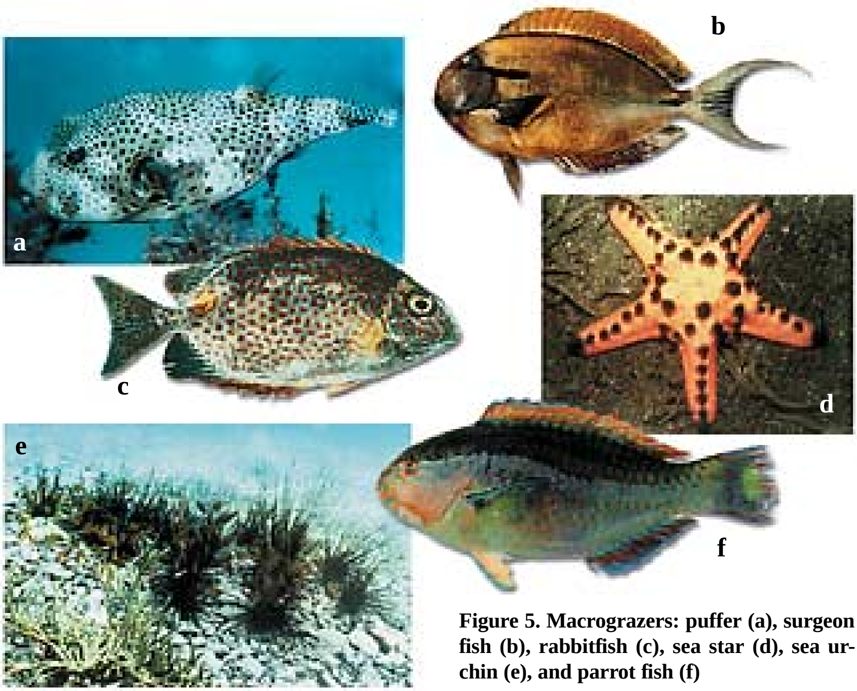


Figure 5. Macrograzers: puffer (a), surgeon fish (b), rabbitfish (c), sea star (d), sea urchin (e), and parrot fish (f)

central area. Grazing becomes more severe as the sea urchin grows bigger, leading to a great reduction in biomass production. At first, a synaptid is a net plankter and becomes visible as a soft pink object residing in between the thalli. As this snake-shaped animal grows bigger, it slips seaweed tips into its "mouth" resulting to the disintegration of the seaweed.

Macrograzers (Fig. 5) are generally adult animals bigger than 5 cm (e.g. echinoderms, fishes)

The common sea star *Protoreaster nodusus* climbs into the seaweed in areas with microalgal-dominated sedimentary bottoms. Once this animal has found the seaweed as its prey, it covers its stomach over the branches causing the eventual death of the covered branches. This is a major disaster among farmed *Kappaphycus* because of branch breakage and ultimate loss of biomass. Though sea star is a bad pest, its grazing habit is restricted to near or within sea grass *(Enhalus acoroides* or *Thalassia hemprichii)* communities.

The sea urchin *Diadema* or *Echinothrix* usually appears as a colony, posing threat of injury to the fisher who try to remove them. This sea urchin has the combined effect of *Tripneustes* and *Protoreaster*.

Rabbitfishes (Siganidae), puffers (Tetraodontidae), surgeon fishes (Acanthuridae), and parrot fishes are common macrograzers. Juveniles of rabbitfish usually appear in schools. They mow the diatoms attached to the edges of seagrasses. As they grow bigger, they feed on *Kappaphycus* available in the seagrass community. Rabbitfishes remove the normally reddish to greenish brown cortex leaving a still-living white skeleton which appears to be the ‘ice-ice’ symptom. The seaweed disintegrates in a few days. As the rabbitfishes or acanthurids grow into adult sizes, they nip off the seaweed branches beginning at the tips until some inhibiting diameter is reached. If the seaweed is not totally grazed, it can regenerate with new and young branches. Constant human presence or enclosing the farm with nets may reduce grazing.

ECOLOGICAL DETERMINANTS IN SITE SELECTION

- free from fresh water run-off
- clear and clean water
- >30 ppt salinity
- 20-40 m min^{-1} water movement
- >30 cm water depth at lowest low tide
- protected bays

STEPS IN CULTIVATION

Preparation of planting materials

Cultivation rope (Fig. 6) – any of the following materials can be used

- Monofilament #110 test lbs
- Polyethylene rope (PER) #6-7
- Flat binder

Figure 6. Cultivation rope: monofilament (a), polyethylene (b), and flat binder (c)

Figure 7. Tying materials: soft plastic rope (a) and monofilament (b)

Figure 8. Support materials: bamboo (a), mangrove post (b), steel bar (c), polypropylene rope (d), and polyethylene rope (e)

Tying materials (Fig. 7)
- soft plastic rope (‘tie-tie’)
- monofilament #160 test lbs

Support materials (Fig. 8)
- bamboo
- mangrove post
- steel bar
- polyethylene rope#12 / polypropylene rope #14

Floater (Fig. 9)
- styrofoam (square or round in shape)
- empty plastic bottles

‘Seedlings’ 100-150 g per cutting

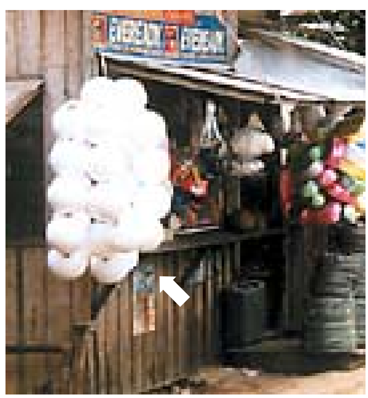


Figure 9. Styrofoam floaters (white arrow) at a local store

Preparation of 'seedlings'

- selection of young branches using a sharp edged knife (Fig. 10)
- tying of individual plant using soft plastic rope
- immersion of the plant in seawater to prevent desiccation

Installation of monolines, bamboo raft and stakes

- Fixed off-bottom long line – stakes (Fig. 11) are pegged to the bottom using a bull hammer

Figure 10. Seedlings are selected (a), tied individually (b, c), and then attached to the cultivation rope (d)

Figure 11. Installation of stakes

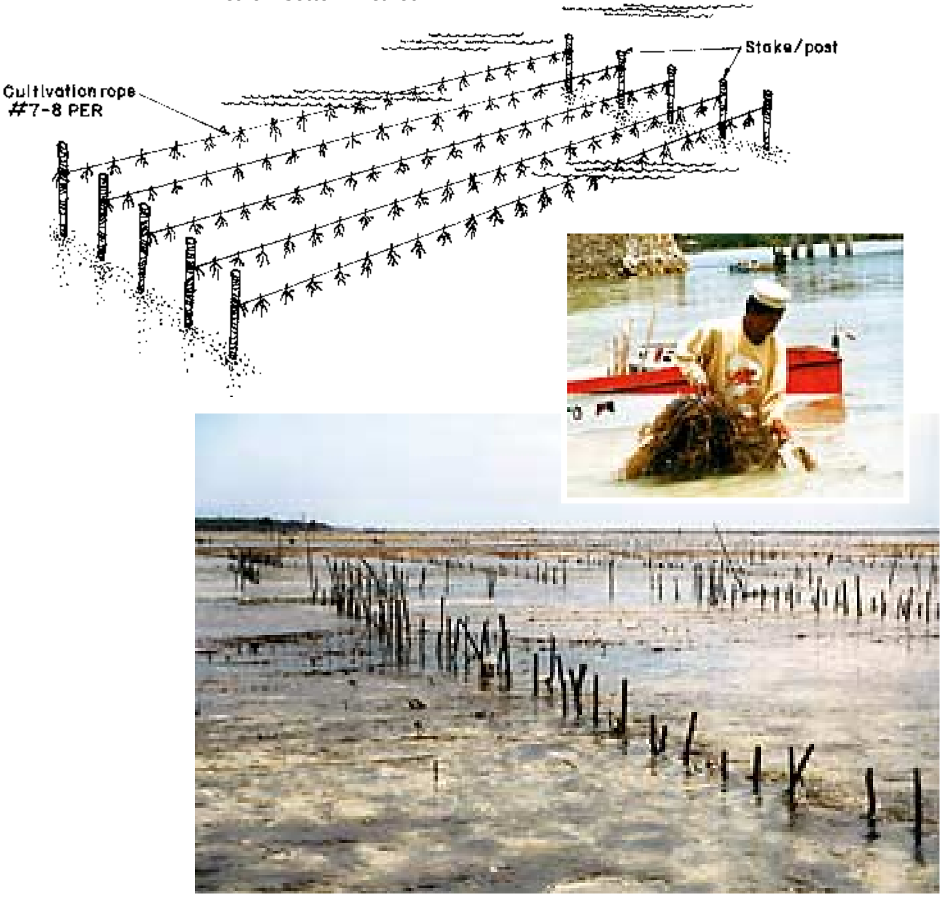
Culture methods

MONOCULTURE

Fixed off-bottom (Fig. 12) or commonly called "parasdas." The farming site should have the following characteristics:

- Shallow water
- Presence of seagrass bed
- Sandy-corally substrate
- Presence of other seaweeds as indicator of growth
- Clean water with little silt

Figure 12.
Fixed off-bottom method



There are two ways of completing the above method:

1) 'Seedlings' are tied first with soft plastic 'tie-tie' in between the basal branches, tied to the cultivation rope while on land and finally tied to the stakes at the farming site

2) both ends of the cultivation rope are tied to stakes previously installed at the farming site and the individual 'seedlings' are finally tied at 15-20 cm apart to the cultivation rope (10-20 m long).This method is only convenient to do during the lowest tide.

Raft long-line (single)

One unit is composed of 4 bamboos arranged in a square shape (Fig. 13). The raft may be installed first at the farming site and 'seedlings' later tied; or the 'seedlings' are first tied to the bamboo raft while it is still on shore and later dragged to the farming site.

Preparation of seedlings follows the same procedure as the fixed off-bottom method.

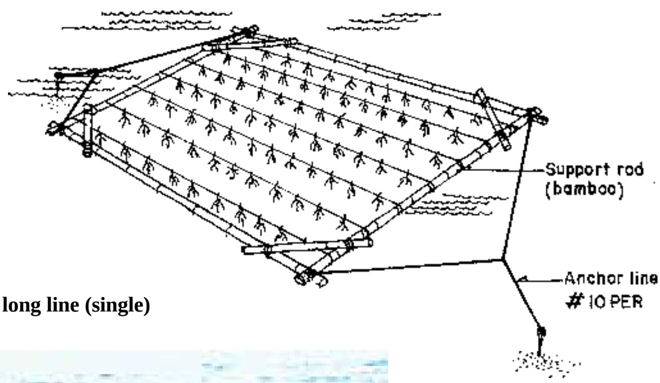


Figure 13. Raft long line (single)

Raft long line (multiple) or commonly called ‘alul’ (Fig. 14). Though most bottom types are suitable, the site should have the following characteristics:

- Moderate to strong water movement
- Protected from heavy waves
- Availability of good anchorage
- Deep water (>10 m high)

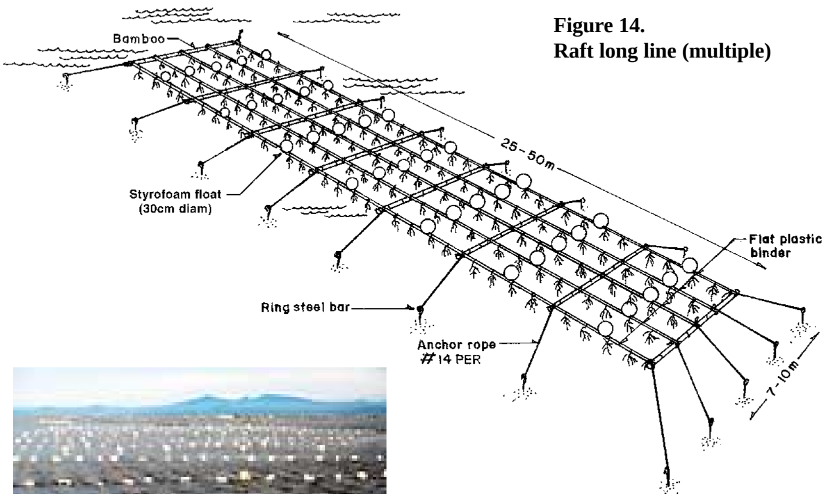


Figure 14.
Raft long line (multiple)

Seven to ten bamboo poles (10-12 cm diam. and 7-10 m long) arranged in parallel design are connected to one another with flat binders to which the ‘seedlings’ are tied. Peripheral cultivation ropes are usually made of 4-5 pieces of flat binders while the rest are usually doubled. Both ends of the entire set-up are anchored with 5-6 pieces of polypropylene rope (#14) using 2 steel bars per anchor rope. Depending on the velocity of the water current, sides of the whole set-up are also supported with anchor ropes and steel bars. The size of one multiple raft ranges from 50 to 70 m long. Round styrofoam float (30 cm diam) is tied at the middle of every segment of the cultivation line after two weeks to keep the seaweeds at a constant depth (25-30 cm) below the water surface.

Hanging long line

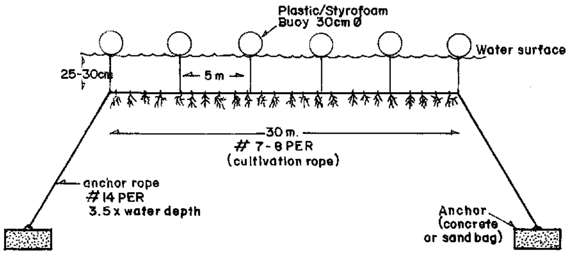
It is used in exposed areas in deep waters (5-10 m high) with moderate to strong water movement, however, it needs a good support system. There are a lot of modifications to this culture method depending on the availability of local resources.

- **Single hanging long line** – one cultivation line is anchored on both ends with a stake or bamboo.
- **Multiple hanging long line** (Fig. 15) – both ends of several cultivation lines arranged in parallel fashion are tied to support lines which are anchored to the bottom with a concrete block, or the ends of the cultivation rope are tied individually to a bamboo pole positioned in perpendicular to the anchor poles.

POLYCULTURE

- Done in cages with any carnivorous fish like grouper, snapper or seabass as the primary fish cultured
- Seaweed is a secondary crop grown on a single raft long line inside the cage
- Presence of a symbiotic relationship between the fish and the seaweed is recognized:
  - fish provides additional nutrients via uneaten feeds and fecal matter
  - seaweed provides shelter to the fish

Figure 15.
Hanging long line



Harvesting, post harvest management, and quality control

HARVESTING

Plants are harvested for drying after 45-60 days of culture. The whole plant can be harvested three ways:

- the individual plant is untied or cut from the cultivation rope – this is commonly practiced in the multiple raft long-line or 'alul' and the hanging long-line
- both ends of the cultivation rope is untied from the stakes – this is practiced in fixed off-bottom or 'parasdas' method, and sometimes in the hanging long line.
- the whole single bamboo raft set up is brought to the shoreline and the seaweeds are untied or cut individually on land

POST-HARVEST MANAGEMENT

Cleaning – clean the newly harvested seaweed to maintain a high quality product. Remove the following:

- non-*Kappaphycus* seaweeds
- sand
- plastic 'tie-tie'
- stones
- wood
- other foreign particles that adhere to the harvested crop

Drying the harvested seaweeds – there are two methods of drying (Fig. 16):

- ground level – mats, fish net, or coconut leaves may be used; constantly turning the seaweeds will accelerate drying
- off-ground level – platform or hanging lines; this method will allow air to circulate more rapidly, thus shortening the drying period

Figure 16. Methods of drying: ground level (a) and off-ground drying like platform (b) and hanging line (c)

DO's in drying

- dry immediately after harvest, i.e. after cleaning/sorting
- keep the seaweeds always clean
- sun-dry for 2-3 days
- maintain the moisture content at 35-39 %

DON'Ts in initial drying

- avoid contact with sand, dust and dirt
- avoid steaming as this causes very rapid degradation of carrageenan
- avoid contact with fresh water as this will reduce salt content, degrade carrageenan, and reduce storage stability

Moisture content of the seaweed is very critical. It dictates its market price. Below are the levels of moisture content that may help seaweed farmers understand the quality of their crops:

Moisture content (%)	Seaweed condition
35 – 39	most stable
> 40	undergo degradation during storage
25 – 35	relatively stable for periods in excess of 12 months (efficient for baling)
15 – 25	extremely stable, but thalli may be too brittle; resists pressure or snap baling
< 15	stable, but can cause processing problems

Storage (Fig. 17) – dried seaweed must be stored in the shortest time possible in clean, cool, dry and well-ventilated places; never store wet seaweed especially in piles; unbaled seaweed usually pick up moisture.

Baling is more advantageous especially in bigger volumes for export purposes because it is easier to handle and shipping costs are reduced.

CRITERIA OF TOP QUALITY DRIED SEAWEED

A top quality dried seaweed has an average 35% (range, 30-39%) moisture content. It has been quickly dried, protected from rain, and has been transported within several days to processors.

The cost of dried seaweed depends on good farming practices by the seaweed farmer on cultivation, drying and storage. The smaller the per-

Figure 17. Storing dried seaweed

centage shrinkage between the dried seaweed at farmsite and the processing plant, the higher is the cost of the seaweed. Incentives are usually given to farmers who practice good post-harvest management. However, if the delivered dried seaweed has a high moisture content (>39%) and with foreign particles, a deduction on the prevailing price is made.

Farming practices

In order to ensure a successful *Kappaphycus* farming, the following should be observed:

Use of good quality 'seedlings' with the following characteristics

- young branches with sharp pointed tips
- no traces of grazing or early signs of 'ice-ice' (whitening of the thallus)
- brittle and shiny branches
- small 'seedlings' (100-150 g)

Periodic visitation (2-3x a week)

- removal of undesirable seaweeds and shells (barnacles)
- removal of attached sediments
- re-tying of loose or fallen cultured seaweed, and loose cultivation rope or stake

If with signs of occurrence of 'ice-ice' disease

- totally harvest crops and use new set of seedlings
- change farming site/farming method
- use lower stocking density

Marketing

The mode of selling dried seaweeds depends largely on the proximity of the growing areas to the main island where the center of trading is located. The existing marketing practices are the following:

Seafarmer → stacker → trader → processor/exporter

Seafarmer → trader → processor/exporter

Seafarmer → processor/exporter

As the marketing chain gets longer, the profit share of the seaweed planter becomes smaller.

ECONOMICS OF SEAWEED FARMING

All farming methods of seaweeds are profitable with returns on investments (ROI) ranging from 115% in single raft long line culture to 984% for fixed off-bottom method. The low capital requirement and relatively high productivity of the fixed off-bottom method are the factors that led to high ROI. All farming systems can afford to pay family labor which was considered as non-cash expense in the cost-and-returns analysis.

The multiple raft long line is used in open sea farming which requires a more durable set-up like the use of steel bars, polypropylene rope and good quality floats. In addition, a motorized boat is needed in open sea farms, unlike in the other systems where non-motorized boats are good enough. Thus it requires a relatively high investment. The ROI in the multiple raft long line method can be increased further by expanding the farm area without increasing the labor cost.

Seaweed farming is a profitable family-based aquaculture enterprise. It can be a good alternative livelihood for fisherfolk families in order to reduce dependence on fishing as a source of income.

Initial investment in the culture of *K. alvarezii* using different techniques

	Fixed off-bottom[a] (ha^{-1})	Single raft long line[b] (ha^{-1})	Multiple raft long line[c] ($500m^{-2}$)			Hanging long line[d] (ha^{-1})
			Value	Economic Life	Depreciation	
A. Capital investment						
Motorized boat*			5,000	7	714	
Non-motorized boat	2,500	2,000	2,880	5	576	2,500
Bamboo raft	1,000					1,000
Bamboo, whole		6,824				
Monoline	7,500	18,529				9,920
Polyethylene rope		600				
Polypropylene rope			3,375	3	1,125	
Flat binder			4,400	3	1,467	
Monofilament cord			1,750	3	583	
Stake	260					224
Steel bar			1,200	5	240	
Tools		100				
Float			1,288	2	644	3,365
Bull hammer			200	5	40	
Total	11,260	28,053	20,093		5,389	17,009
B. Working capital	7,490	28,704	29,183			8,455
C. Total investment	18,750	56,757	49,276			25,464

[a] Hurtado-Ponce et al, 1996. [b] Samonte et al, 1993. [c] Hurtado and Agbayani, 2000. [d] Hurtado-Ponce et al, 1996. * Motorized boat costs P25,000. For a 500 m^2 farm, P1,250 is the allocated cost. Non-motorized boat costs P8,000. For a 500 m^2 farm, P400 is the allocated cost.

Cost-and-returns analysis of the different culture techniques

	Fixed off-bottom[a] (ha^{-1})	Single raft long line[b] (ha^{-1})	Hanging long line[d] (ha^{-1})
FIRST CROP			
Production, kg (dry wt)	9,300	7,647	7,150
Revenues (PhPeso)	69,750	52,731	63,625
Operating expenses			
Cash:			
Seedlings	4,900	16,595	5,800
Labor: Installation	1,300	3,200	1,120
Tying of seedlings	390		335
Bamboos			
Harvesting			
Plastic strip	900	6,300	1,200
Interest expense (12%)	2,250	6,811	3,056
Sub-total	9,740	32,905	11,510
Non-cash:			
Family labor	1,800	7,040	1,800
Depreciation	1,498	6,713	1,350
Sub-total	3,298	13,753	3,150
SECOND & THIRD CROPS			
Production (kg)	18,600	14,061	
Revenue	139,500	105,462	107,250
Operating expenses			
Cash:			
Seedlings	0	0	0
Labor: Installation	2,600	6,400	2,240
Tying	780	0	670
Bamboos			
Harvesting			
Materials: Tie-Tie	1,800	12,600	2,400
Sub-total	5,180	19,000	5,310
Non-cash:			
Family labor (harvesting)	3,600	14,080	3,600
Depreciation	2,996	13,426	4,051
Sub-total	6,596	27,506	7,651
Total expenses	24,814	93,164	27,621
Net income before tax	184,436	65,028	143,253
Production cost (kg^{-1})	1.12	0.23	0.26
Return on Investment (%)	984%	115%	563%
Payback period (years)	0.10	0.72	0.17

	Multiple raft long line[c] (500 m^2 only)
FOR FIVE CROPS	
Quantity (kg, 7:1, dwt/crop)	2,314
Revenue (PhP, 23/kg, 5 crops/yr)	266,110
Operating expenses	
Cash:	
Seedlings (PhP 2-3/kg)	16,000
Soft tie-tie	250
Bamboos	280
Gasoline, oil and engine maintenance	4,600
Labor	
Tying of seedlings	2,000
Installation of raft	2,400
Harvesting	1,000
Miscellaneous expenses (% of seedlings, soft tie-tie, bamboos, gas, oil, and engine maintenance	2,653
Sub-total	29,183
Non-cash	
Family labor-preparation of seedling/drying	1,500
Depreciation	1,078
Sub-total	2,578
Total cost run^{-1}	31,761
Total cost yr^{-1}	158,804
Net income before tax (5 crops)	107,306
Return on investment (ROI, %)	218%
Payback period (yr)	0.437

[a] Hurtado-Ponce et al, 1996. [b] Samonte et al, 1993. [c] Hurtado and Agbayani, 2000.
[d] Hurtado-Ponce et al, 1996

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Representing the Member Countries is the Council of Directors, the policy-making body of SEAFDEC. The Chief administrator of SEAFDEC is the Secretary-General whose office, the Secretariat, is based in Bangkok, Thailand.

Created to develop fishery potentials in the region in response to the global food crises, SEAFDEC undertakes research on appropriate fishery technologies, trains fisheries and aquaculture technicians, and disseminates fisheries and aquaculture information. Four departments have been established to pursue the objectives of SEAFDEC.

- The Training Department (TD) in Samut Prakan, Thailand, established in 1967 for marine capture fisheries training
- The Marine Fisheries Research Department (MFRD) in Singapore, established in 1967 for fishery post-harvest technology
- The Aquaculture Department (AQD) in Tigbauan, Iloilo, Philippines, established in July 1973 for aquaculture research and development
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