Farming techniques for seaweeds

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Photos courtesy of the AQD seaweed team

Farmers could earn more from seaweed culture than from milkfish, mud crab, tiger shrimp or tiger shrimp-tilapia culture. The economics of these systems have been computed by AQD researchers as follows:

Species cultured	Total investment (ha)	Net income (per ha per yr)	Return on investment (%)	Payback period (yr)
Kappaphycus	18,750	187,896	1,003	0.10
Milkfish	18,688	14,694	79	1.10
Mud crab	88,201	58,585	66	1.17
Tiger shrimp	32,906	11,686	36	2.10
Tiger shrimp + tilapia	34,024	23,697	70	1.20

With a good carrageenan market worldwide, farmers could not go wrong on *Kappaphycus* and other seaweeds.

BOTTOM LINE CULTURE METHOD FOR *KAPPAPHYCUS*

The fixed off-bottom monoline or bottom line method of cultivation is commonly used in commercial farms. This is due to lower cost of materials, labor and maintenance; higher net income and return of investment; and shorter payback period as compared to the net, raft monoline and hanging longline methods.

Here's how bottom line culture is done:

1 CHOOSE A GOOD SITE

Kappaphycus farming areas usually have moderate water movement, sandy to corally bottom, far from river mouths and protected against destructive waves.

Clear the chosen site of undesirable organisms.

2 CONSTRUCT THE MONOLINES

Stake wooden anchors into the substratum (like mangrove branches), about 6-10 meters apart. Tie in the nylon lines (see illustration).

Distance of the rows of stakes is 1 m apart. The nylon lines is 0.3-0.5 m away from the bottom depending on water depth during low tide.

3 SEEDLINGS AND FARM MAINTENANCE

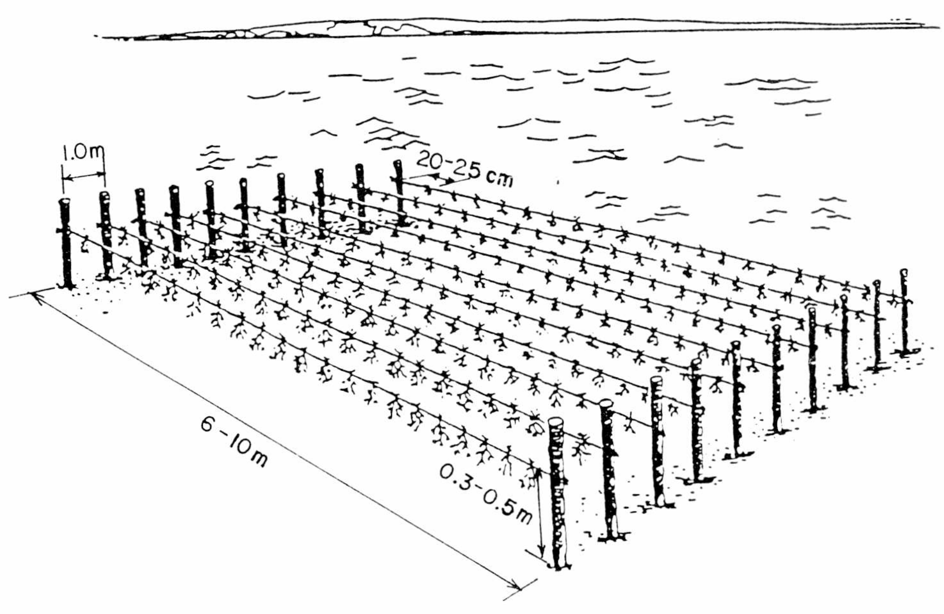
Tie the *Kappaphycus* seedlings or cuttings to the nylon at 20-25 cm intervals using soft plastic materials. Replace poorly growing and lost seedlings, and remove grazers such as sea urchins and starfishes and epiphytes growing on seaweed as these compete for nutrients, light and space.

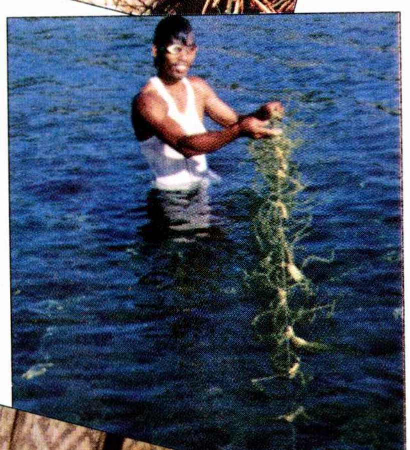
4 HARVEST AND OTHER NOTES

Harvest after 2-3 months. Take the whole plants but leave enough for the replanting of new cuttings. Sun-dry seaweeds before selling to processors. Pack in sacks.

As noted on the table above, net income and return-on-investment is

Fixed off-bottom monoline method of farming Kappaphycus *(from Trono 1994). Not drawn to scale.*





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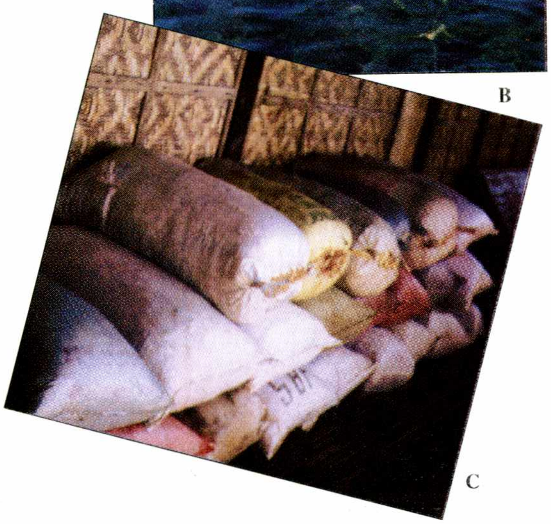

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better than other culture species. These can be gained from a total investment and working capital of only ₱18,750, mostly the cost of monoline ropes, posts, and non-motorized banca. Succeeding crops will need a little over ₱5,000 for operating expenses (labor for seeding and plastic strips).

(These estimates were computed in 1995 based on seaweed farms in Panagatan Cays, Antique. - Ed.)

POND CULTURE OF *GRACILARIA*

The agar-rich *Gracilaria* can be cultivated in ponds and in canals. The industry method is similar to planting rice where seaweed cuttings are directly staked onto the bottom. AQD, however, modified this practice by using a hapa net in growing *Gracilaria* in brackishwater ponds (see illustration). These modifications are expected to reduce the amount of grazing by fishes (like tilapia) that are not totally eradicated during pond preparation. These also make harvesting and checking the stock easier.

1 USE EXISTING OR IDLE BRACKISHWATER POND

Drain the pond, clear it of unwanted plants and debris, and sun-dry. Apply lime only if it is necessary. Let in water, and maintain at 60-80 cm throughout the culture period.

2 INSTALL THE HAPA NET

Install the hapa net (1 x 0.5 x 0.7 m and 5 mm mesh, illustration below) with the bottom embedded in the pond. Sixteen hapa nets may be used per 200 m^2 pond.

Evenly distribute young *Gracilaria* fronds or vegetative fragments (10-15 cm long). Use about 200-250 grams of these fronds per hapa net.

3 TAKE CARE OF THE STOCK HARVEST

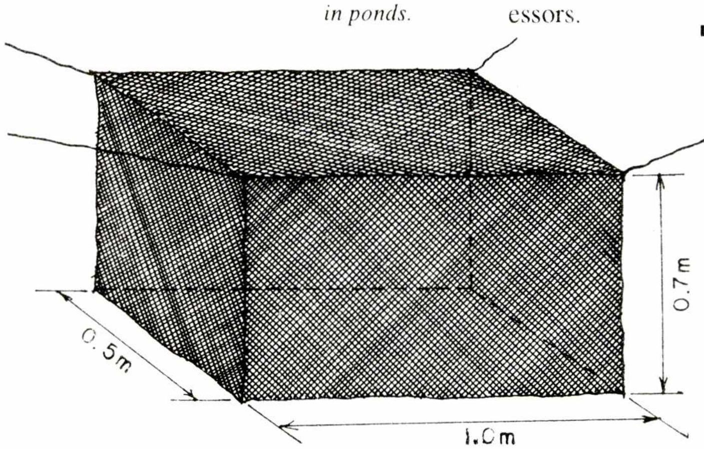
Change water following the tidal cycle. Fertilize the pond every two weeks using 3 kg per ha of urea.

Clean the hapa nets regularly. Scoop out any *lab-lab* that floats to the surface.

Gracilaria may be harvested after 45-60 days of culture. Like *Kappaphycus*, dry the *Gracilaria* before packing and selling to agar processors.

☞ page 16

Hapa nets may be used in Gracilaria *culture in ponds.*



FARMING TECHNIQUES FROM PREVIOUS PAGE ...

AQD researchers have also tried the use of netcages in a protected cove to culture *Gracilaria*. The netcage has the same advantage as the hapa net: it reduces grazing. AQD researchers have noted that about 25-75% of *Gracilaria* show grazing damage by siganid, parrotfish, and glassfish to name a few.

Polyculture of seaweed with fishes is also feasible, giving added income to fishfarmers while maximizing the use of the netcage. AQD researchers, however, caution that their results are still experimental and the economic feasibility of the netcage method will need more careful study.

The netcage design is shown below. The stocking density is the same as in hapa nets in ponds.

Gracilaria's rotten thallus syndrome

Like animals, plants do get sick and seaweed is no exception. A white to pinkish discoloration on the seaweed *Gracilaria* -- maintained in tanks -- is one sure sign of the gradual disintegration of the thallus. This syndrome, notes an AQD researcher, is associated with and may be caused by agar-digesting bacteria. A lot of these bacteria, some 1.42×10^7 bacterial cells, can be found per gram of affected thalli.

Based on biochemical tests, the bacterial isolates from *Gracilaria*'s rotten thalli have been classified as belonging to the genus *Vibrio*.

Diseases usually result from the interplay of the condition of the host (in this case, the seaweed), some ecological factors that can weaken its disease resistance (like reduced flow rate of water for tank-held seaweed stock), and the advantage that potential pathogens (like *Vibrio*) gain. The lesson for seaweed growers is to take extreme care in avoiding water pollution in their farms, and in being more active and more aware about environmental and sustainability issues in general. Seaweed farms are part of a coastal ecosystem that is affected by terrestrial ecosystems, too.

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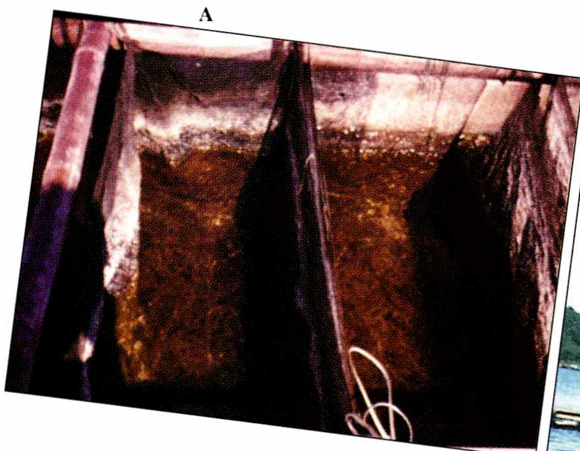

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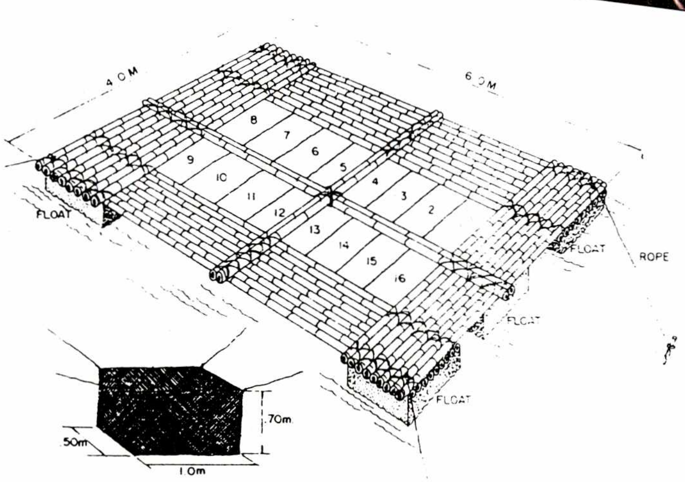
Netcage for Gracilaria *culture in the open sea. (A-B)* Gracilaria *cage culture at AQD's Igang Marine Substation.*



BAILINAE, THE NEW SEAWEED ON THE BLOCK

AQD researchers have surveyed the seaweeds of Panay island in west central Philippines and they recorded 41 new seaweeds for Panay. One such record is *Gracilariopsis bailinae* (=*G. heteroclada*) which are found on protected bays, estuarines / rivers, and creeks with sandy-muddy substrate; and sometimes in brackishwater ponds.

AQD researchers proceeded to test the *rheological properties of agar extracted from *G. bailinae*. A 60-minute extraction produces agar gels with the highest breaking strength (1,013 g), the maximum cohesiveness (7.4 mm), the greatest breaking energy (7,481 g per mm), and the greatest stiffness (137.3 g per mm). Gelling temperature ranges 28-40°C and melting temperature 70-92°C. These values suggest a strong, firm and rigid gel. Strong gels are important because these are resilient, elastic, relatively transparent, relatively permanent, and thermo-reversible. *G. bailinae*'s gel may be used in bacteriology.

With this potential use in mind, AQD researchers assessed the investment requirements and production costs (tables on this page). A costs-and-returns analysis is found next page. Initial investment in a 0.1 ha farm is as little as ₱ 4,000 (computed in 1997) and the first crop costs ₱1,500. The next 8 crops would cost only ₱300. Return on investment is over 500% in 2 months.

Although the fixed bottom longline method is used in the financial analysis, commercial farms in Iloilo and Surigao use the "rice-planting" method which is a cheaper investment. The fixed bottom longline is still a demonstration project of BFAR-FAO-UNDP in Sorsogon.

☞ page 18

Investment for a 0.1 hectare *Gracilariopsis bailinae* farm using the fixed-bottom longline method (from Hurtado-Ponce et al. 1997).

	Quantity	Unit cost	Total	Economic life (year)	Annual depre-ciation
Capital assets					
Drying platform (bamboo)	1 unit	₱ 1,000.00	1,000.00	2	500.00
Polyethylene rope (No.7)	4 rolls	70.00	280.00	5	56.00
Basins/pails (big)	1 pc	400.00	400.00	2	200.00
Subtotal			1,680.00		756.00
Working capital (first crop)			1,420.00		
Total investment			₱ 3,100.00		

Computed using the straight line method by dividing cost of asset by the economic life of asset. Value of the asset scrap is assumed to be zero.

Cost of *Gracilariopsis bailinae* cultivation using fixed bottom longline method (0.1 ha) (from Hurtado-Ponce et al. 1997)

	Quantity	Unit cost	Total
Production cost (first crop)			
Seed plants (kg)	500	₱ 2.00	1,000.00
Plastic tie-tie (rolls)	1	45.00	45.00
Mangrove posts (pcs)	240	0.50	120.00
Hired labor (man day)	3	60.00	180.00
Depreciation			75.00
Subtotal			1,420.00
Succeeding crops (2nd-9th crop)			
Plastic tie-tie (roll)	1	45.00	45.00
Hired labor (man-day)	3	60.00	180.00
Depreciation			75.00
			300.00
Subtotal (8 crops)			2,400.00
Annual production cost (9 crops)			3,820.00

Exclude opportunity cost of labor and capital

*rheology is the science dealing with deformation and flow of matter

Cost and returns from 0.1 hectare *Gracilariopsis bailinae* farm using fixed bottom longline method (from Hurtado-Ponce et al. 1997)

	Quantity	Unit price	Total
Seedling density (kg per 1,000 m^2)	500		
Average yield (fresh weight, kg)*	2,220		
Less: seedling allocation (kg)	500		
Net yield (fresh, kg)	1,720		
Dry yield (20% moisture content, kg)	344	₱ 7	₱ 2,408.00
Net returns			
First crop			
Gross returns			2,408.00
Less production cost			1,420.00
Net returns for first crop			988.00
Succeeding crops (2nd to 9th crop)			
Gross returns			19,264.00
Less production costs			2,400.00
Net returns for the succeeding crops			16,864.00
Annual net returns 1000 m^2			17,852.00
Return on investment (%)			575.87
Payback (years)			0.16

*at 4.5% average (specific) growth rate.

"Rice-planting" *G. bailinae*

For *G. bailinae*, the tried and true "rice-planting" method can be used by seaweed growers. The following technique is drawn from the experiences of 8 *Gracilaria* growers in Panay who were interviewed by AQD researchers.

1 USE PONDS OR CANALS

Farm size can range 0.5 to 5 hectares for ponds and 825-7,055 m^2 for canals. Pond bottom should be sandy-muddy. Use *G. bailinae* found in the locality as seedstock.

2 "RICE-PLANT" THE SEEDLINGS

Start culture in June-July although a November-December start is also practiced. Cut the thalli into 15-20 cm or weigh in 15-20 g of seaweed. Stake this thalli bunch onto the pond or canal bottom. Allow for 10-15 cm space between the staked bunches.

3 STOCK MAINTENANCE HARVEST

Gracilaria are usually left alone, but change water if possible and keep the pond or canal clean of debris. Harvest after 45-60 days in the ponds or after 15-20 days in canals. But leave about one-third to serve as seedstock for the succeeding period.

Sun-dry the harvest for 2-3 days using old fish nets or bamboo slats. Pack in sacks and store in a cool, dry place. Growers may opt to accumulate a bigger volume to await a higher price.

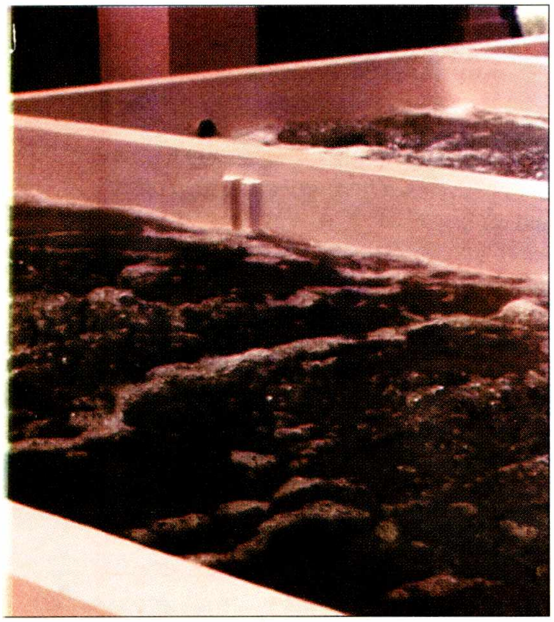
4 OTHER NOTES

Growers who plant in ponds can have 12-16 croppings in a year; in canals, 16-24. Ponds can produce 3-4 tons of dried seaweeds per ha per year or an average 450 kg per ha per crop. In canals, yields of 7-14 tons dried seaweeds per ha per year is attainable or an average 1.3 tons per ha per crop.

Initial investment for a 1-ha pond is about ₱16,000 (computed in 1992); in a 1-ha canal, ₱4,600. This covers pond development, drying platform, dug-out, non-motorized banca, and working capital for the first crop.

Investment for the second and succeeding crops costs about ₱1,500 for both pond and canal. This includes family labor, caretaker's salary, hired labor, marketing expenses, land tax, permit and depreciation.

Growers can get an income of ₱24,000 from ponds or ₱41,800 from canals (total of 8 crops).



Seaweed tanks at AQD's Tigbauan Main Station in Iloilo, west central Philippines

AQD's seaweed R&D priorities

Gracilaria species

- genetics and creation of seedbank
- monoculture and polyculture in ponds
- use as biofilter in semi-intensive and intensive shrimp ponds
- product utilization, eg. as feed ingredient
- village-level processing of agar
- socioeconomic studies in seaweed-dependent communities

Kappaphycus alvarezii

- genetic studies for strain selection
- development of seed production technology

Sargassum

- natural recruitment of spores using artificial concrete blocks
- transplantation of juvenile plants
- establishment of artificial *Sargassum* beds

PUBLICATIONS OF AQD RESEARCHERS ON SEAWEEDS (1990-PRESENT)

Chavoso EAJ, AQ Hurtado-Ponce. 1995. Effects of stocking density and nutrients on the growth and agar gel of *Gracilariopsis bailinae* (Gracilariales, Rhodophyta). The Philippine Scientist 32: 27-33.

de Castro TR. 1993. Evaluation of agar from three species of *Gracilaria* from Panay and Guimaras Islands. The Philippine Scientist 30: 41-47.

de Castro TR. 1993. Effects of gel depth and gel surface area on agar gel strength. The Philippine Scientist 30: 100-103.

de Castro TR. 1993. Improvised filter unit for agar extraction / filtration. The Philippine Scientist 30: 97-99.

de Castro TR, NG Guanzon Jr, MRJ Luhan. 1991. Assessment of stocks of a natural *Gracilaria* population on Panay Island, Philippines. Botanica Marina 34: 383-386.

de Castro TR, NG Guanzon Jr. 1993. Growth of *Gracilaria* sp. (Gracilariales, Rhodophyta) in brackishwater ponds at different stocking densities. The Israeli Journal of Aquaculture - Bamidgeh 45: 89-94.

Guanzon NG Jr, TR de Castro. 1992. The effects of different stocking densities and some abiotic factors on cage culture of *Gracilaria* sp. (Rhodophyta, Gigartinales). Botanica Marina 35: 239-243.

Hurtado-Ponce AQ. 1990. Vertical rope cultivation of *Gracilaria* (Rhodophyta) using vegetative fragments. Botanica Marina 33: 477-481.

Hurtado-Ponce AQ. 1992. Influence of extraction time on the rheological properties of agar from some *Gracilaria* species from the Philippines. Botanica Marina 35: 441-445.

Hurtado-Ponce AQ. 1992. Rheological properties of agar from *Gracilariopsis heteroclada* (Zhang *et* Xia) Zhang *et* Xia (Gracilariales, Rhodophyta) treated with powdered commercial lime and aqueous alkaline solution. Botanica Marina 35: 365-369.

Hurtado-Ponce AQ. 1992. Cage culture of *Kappaphycus alvarezii* var. *tambalang* (Gigartinales, Rhodophyceae). Journal of Applied Phycology 4: 311-313.

Hurtado-Ponce AQ. 1993. Carpospore germination and early stages of development in *Gracilaria edulis* (Gmelin) Silva and *Gracilaria rubra* Chang et Xia (Gracilariales, Rhodophyta). The Philippine Scientist 30: 34-40.

Hurtado-Ponce A. 1997. Assessment of the seaweeds industry. IN: Export Winners / Philippines. Department of Science and Technology and FAO-UNDP.

Hurtado-Ponce AQ, HB Pondevida. 1997. The interactive effect of some environmental factors on the growth, agar yield and quality of *Gracilariopsis bailinae* (Zhang et Xia) cultured in tanks. Botanica Marina 40: 217-223.

Hurtado-Ponce AQ, MRJ Luhan, NG Guanzon Jr. 1992. Gathering of economically important seaweeds in western Visayas, Philippines. The Philippine Scientist 29: 40-47.

Hurtado-Ponce AQ, MRJ Luhan, NG Guanzon Jr. 1992. Seaweeds of Panay. SEAFDEC Aquaculture Department, Iloilo, Philippines. 114 pages.

Hurtado-Ponce AQ, RF Agbayani, EAJ Chavoso. 1996. Economics of cultivating *Kappaphycus alvarezii* using the fixed-bottom line and hanging-long line methods in Panagatan Cays, Caluya, Antique, Philippines. Journal of Applied Phycology 105:105-109.

Hurtado-Ponce AQ, GPB Samonte, MR Luhan, NG Guanzon Jr. 1992. *Gracilaria* (Rhodophyta) farming in Panay, western Visayas, Philippines. Aquaculture 105: 233-240.

Lavilla-Pitogo CR. 1992. Agar-digesting bacteria associated with 'rotten thallus syndrome' of *Gracilaria* sp. Aquaculture 102: 1-7

Luhan MRJ. 1992. Agar yield and gel strength of *Gracilaria heteroclada* collected from Iloilo, central Philippines. Botanica Marina 35: 169-172.

☞ page 25

with 5-6 crops a year. There are also 10 processors for semi-refined carrageenan, three processors for refined carrageenan, and 10 carrageenan exporters.

The Seaweed Industry Association of the Philippines noted that the country produced about 24,000 tons of *Kappaphycus* (dry weight) in 1996 valued at almost US$20,000. The country processed semi-refined and refined carrageenan valued at US$31 million and US$23 million, respectively. Export sales in 1996 for dried *Kappaphycus*, semi-refined carrageenan and refined carrageenan amounted to over US$124 million, making the Philippines the largest supplier in the world market.

Future Prospects

With the currency crisis overshadowing the region, it is hard to determine the future of the seaweed market. Indonesia which is the only alginate producer and has a large market should focus on developing the industry. Malaysia and Thailand are foreseen to continue importing the phycocolloids because there is no viable large-scale farming areas in these countries. On the other hand, the carageenan industry in the Philippines is well-established, and is expected to maintain, if not increase, its output in the coming years.

REFERENCES

Antoro A, Sutimantoro. 1996. Country reports - Indonesia, p.87-98. *In*: Regional Study and Workshop on the Taxonomy, Ecology and Processing of Economically Important Red Seaweeds. NACA Environment and Aquaculture Development Series. No 3. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.

FAO Fishery Information, Data and Statistics Unit. 1997. Aquaculture production statistics 1986-1995. FAO Fisheries Circular. No. 815, Rev.9. Rome, FAO. 195p.

INFOFISH. 1996. Uses and markets for seaweed products: Malaysia and Thailand. INFOFISH International 4:22-26.

Llana MEG. 1996. Country reports - Philippines (Part I). p.151-161. See FAO/NACA above.

McHugh DJ. 1996. Uses and Markets. FAO/GLOBEFISH Research Programme, Vol. 48. Rome, FAO. 73p.

Saad R. 1996. Country reports - Malaysia, p.99-105. See FAO/NACA above.

Srimanobhas V, Kungsuwan A. 1996. Country report - Thailand, p.151-161. See FAO/NACA above.

Cage polyculture (seaweed with grouper) at AQD's field office-laboratory in Malalison Island, west central Philippines. This trial was part of AQD's alternative livelihood program within the Community Fishery Resource Management Project.

CULTURE ... FROM PAGE 19

Luhan MRJ. 1996. Biomass and reproductive states of *Gracilaria heteroclada* Zhang et Xia collected from Jaro, central Philippines. Botanica Marina 39: 207-211.

Luhan MRJ, AQ Hurtado-Ponce, NJ Guanzon, GV Trono. 1992. New records of marine macrobenthic algae of Panay and Guimaras Islands. Philippine Journal of Science 121: 435-452.

Samonte GPB, AQ Hurtado-Ponce, RD Caturao. 1993. Economic analysis of bottom line and raft monoline culture of *Kappaphycus alvarezii* var. *tambalang* in western Visayas. Aquaculture 110: 1-11.

ADDITIONAL REFERENCES FOR THIS ARTICLE

Agbayani RF. 1990. Economics of milkfish culture in the Philippines. *In*: H Tanaka, KR Uwate, JV Juario, CS Lee & R Foscarini (eds). Proceedings of the Regional Workshop on Milkfish Culture Development in the South Pacific, Tarawa, Kiribati, 21-25 November 1988. Suva, Fiji: South Pacific Aquaculture Development Project, FAO. p.101-108.

BFAR. 1995 Philippine Fisheries Profile. 47p.

Samonte GPB, RF Agbayani. 1991. Pond culture of mud crab (*Scylla serrata*): an economic analysis. *In*: CA Angell (ed). Report of the Seminar on the Mud Crab Culture and Trade held at Surat Thani, Thailand, November 5-8, 1991. Madras, India: Bay of Bengal Programme. p.225-234.

Samonte GPB, RF Agbayani, RE Tumaliuan. 1991. Economic feasibility of polyculture of tiger shrimp (*Penaeus monodon*) with Nile tilapia (*Oreochromis niloticus*) in brackishwater ponds. Asian Fisheries Science 4:335-343.

Trono GC Jr. 1994. *Eucheuma* and *Kappaphycus*: taxonomy and cultivation. *In*: M Ohno & AT Critchley (eds). Seaweed Cultivation and Marine Ranching, First Edition. Yokosuka, Japan: JICA. p.75-88.