Proceedings of the National Seaweed Planning Workshop

AQ Hurtado   TR de Castro-Mallare
NG Guanzon Jr.   Ma. RJ Luhan
Editors








SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
Aquaculture Department

Proceedings of the National Seaweed Planning Workshop

held on August 2-3, 2001
SEAFDEC Aquaculture Department
Tigbauan, Iloilo

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SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
Aquaculture Department
Tigbauan, Iloilo, Philippines
April 2002

ISBN 971-8511-57-1

Published and printed by:
Southeast Asian Fisheries Development Center
Aquaculture Department
Tigbauan, Iloilo, Philippines

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FOREWORD

Seaweed forming is one of the major livelihoods among coastal communities in the Philippines, particularly to some 180,000 families in the Sulu Archipelago. In 1999, the Philippines exported more than 35,000 tons of dried seaweeds (US$ 44M) making the country the 4th largest producer of seaweeds and 8th largest producer of carrageenan in the world. However, improper post-harvest management (i.e. cleaning; drying by salting or steaming; adulteration of seaweeds with sand, dust, and dirt for added weight; storage; and baling) reduces quality, which eventually dictates the market price.

The National Seaweed Planning Workshop was organized by a collaborative effort of SEAFDEC Aquaculture Department (AQD) and the Bureau of Fisheries and Aquatic Resources (BFAR) for the formulation of a Code of Practice for the Seaweed Industry in order to minimize industry malpractices and to sustain its position in the international market.

The National Seaweed Planning Workshop invited several seaweed industry associations, and representatives from the government, NGOs and academic and research organizations conducting seaweed research and development to discuss the research and development programs of the different participating agencies, identify and validate problems and concerns of the seaweed industry, and agree on strategies of solving problems in seaweed farming like disease management, post-harvest facilities and research funding. This proceedings documents the National Seaweed Planning Workshop. Hopefully, the contributions would help in the drafting of the Code of Practice in attaining a sustainable seaweed industry.

ROLANDO R. PLATON
Chief, Aquaculture Department
SEAFDEC
April 2002

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BACKGROUND OF THE WORKSHOP

In the Philippines, more than 600 species of marine macrobenthic algae belonging to three major groups- Chlorophyta, Phaeophyta, and Rhodophyta, have been reported. Of the more than 600 species reported in the Philippines, 365 species have been documented to be economically important. Depending on their species, they may be used as food, as a sources of agarophytes, carrageenophytes, alginophytes, and others.

In 1990, the total seaweed production was 51M tons. At present, 14 companies are engaged in the processing and manufacture of carrageenans. These enterprises form the base of the seaweed industry with equipment assets of more than US$36M in 1990 which provided employment to more than 10,000 personnel.

The seaweed industry is not without problems. Despite encouraging information, the growth of the seaweed industry in the Philippines has not reached its maximum potential. In one seaweed meeting attended by researchers, entrepreneurs, government and non-government officials, the need for an integrated, wholistic program for the entire seaweed industry was articulated. Thus, the planning workshop on the role of the different sectors in the seaweed industry was organized to put together a national seaweed program to address the problems of the seaweed industry. Specifically, it aimed to assess industry practices, identify problems and remedial measures, and identify projects to solve problems related to the industry in farming systems, export/processing, government thrusts, and research.

Kappaphycus Farming: Farmer's Experience

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My experience in seaweed farming started in 1995, but the concept was initiated after my visit to the United States of America in the early nineties. It came to my surprise during my journey to that country to know that farmers own vast land areas and that they are among the wealthiest people in the region. Ironically, when you talk about farmers in the Philippines, they are the people living in the poverty line or in the rural places.

When I came back from the tour, the thought of farming seaweed dawned on me. Not for the reason that I wanted to be wealthy like the American farmers but for a novel purpose of initiating a small of seaweeds farm considering the resources available in Zamboanga. Though there have been talks that majority of group farming was not successful, the idea didn't dampen my enthusiasm.

The growing demand of seaweeds would likely continue, hence, the only way to sustain the demand of our company is to put up farms that will produce the necessary quantity and quality without relying from others.

History

Sometime in 1995, my family started farming *Kappaphycus striatum* in Arena Blanco, Zamboanga City. Initially, 10 families were engaged in deep sea farming using the multiple raft method. Two rafts measuring 500 m^2 each were given to a family and a total area of 1 ha was planted. Five small and two medium size boats were provided for planting and harvesting purposes. Likewise, a small platform for drying the harvested seaweed was built as part of the shelters of the planters. The average monthly production was 60 t fresh weight or an equivalent of approximately 10 t dry weight.

Through the years, a lot of people migrated from Sulu and Tawi-Tawi to Zamboanga City and engaged in seaweed farming through our assistance. As the pioneering family in seaweed farming in this area, shelter, food, and other basic necessities for living were provided on a credit basis during the planting season. After harvest, all credits were deducted from the sales. Omar General Trading played a significant role in seaweed farming in this area since it provided farming materials ("tie-tie", ropes, binders, styrofoam floats, steel bars) and financial assistance for the basic necessities of the people.

The method of culturing the seaweed is unique and it is only in this part of the Philippines where the multiple raft long line method is practiced. It is adopted in deep seawater at > 5 m high. However, it is the most expensive way of farming seaweed. The cost of one 500 m^2 raft is about PhP 15,000.00 (bamboo, tie-ties, ropes, anchor, binders, labor and seedlings). The fixed off-bottom and hanging long line monoline methods, which are less expensive are mostly used in Sulu and

Tawi-Tawi.

After a while, a lot of farmer groups in the neighboring areas replicated the culture technique because they found the concept quite adoptable. They believe that seaweed farming is more profitable than fishing as a source of livelihood. Because of the expansion of cultivation areas brought by an increased number of seaweed planters, Tictauan Is. and its neighboring areas increased its monthly production from 400 to 20,000 bags of dry *'cottonii'* seaweed.

Production

The Kasanyangan Seaweed Planters Association (KSPA) was organized as a result of the increased number of seaweed planters in the area. It is composed of 14 farmer groups in different production areas in Zamboanga City Tictabon Is., Arena Blanco, Pangapuyan, Layag-Layag, Bana Lipa, Manicaan, Sinunuc, and Caragasan. It has a total membership of 378 comprising more than 300 families. Today, there are 768 rafts occupying > 38 hectares of sea area. The production capacity ranges from 60 to 2,304 tons fresh weight and 10 to 391 tons of dry *'cottonii'* seaweed a month. This only refers to our farm production alone.

There was a tremendous increase in growth in terms of number of farmers and the production output. We are proud to say that we played a vital role in the industry more than anyone else. No other companies would think of doing the same thing. Some have tried but they failed.

The success of seaweed farming in this area as initiated by my family is a big milestone in the seaweed industry and more importantly to the hundreds of marginal fisher folk in this place despite the absence of technical and financial support from the government and academic institutions. The role of KSPA and Omar General Trading in improving the standard of living of the fisher folk is beyond question.

Common problems

Several problems like disease, farming practices, quality, price, and natural calamity were encountered since the beginning, however, the magnitude decreased as seaweed planters made adjustments in their farming practices as understanding of the biology and ecology of the seaweed was increased.

- the occurrence of "ice-ice" disease had damaged 60% of the farm output in the area. The adverse effect caused farmers to alternate fishing and seaweed farming as a source of livelihood. Large amount of money is needed to finance the rehabilitation of a farm to bring production levels back to where it was before. It is estimated that PhP 8,000.00 per raft is needed for rehabilitation.

- farmer's malpractices. At present, salting the newly harvested seaweed is a crucial issue being discussed in the industry. The practice of salting is done during the rainy season among farmers. Moderate salting enhances the drying process of the raw material. The only problem is that, farmers abusing the use of salt. They believe that it will increase the weight of their produce giving them extra profit but in reality, it adversely affects the quality of the carrageenan. Salting is also practiced in Indonesia. Premature harvesting of

30-45 day old young plant is another issue. Culturing the seaweed beyond 45 days is somewhat not practical because the seaweed will fall due to its heavy biomass. The initial biomass of the 'seedling' is approximately 350-500 g, hence, growth period is shorter.

- unstable price of dried seaweed is another problem for the Zamboanga produced seaweed. It is priced PhP 2.00 lower than in other places. The sudden drop of prices early last year from PhP 24.00 down to PhP 14.00 was painful for the planters, thus, the planters were discouraged. There is discouragement among buyers in the area. Brokers of some traders and exporters in the city go to the farms pirating the supply of our farmers by offering a price higher than ours and less restrictions on quality. Definitely, the farmers find the offer quite enticing because they would no longer need to be conscious on the restrictions concerning quality. These farmers are convinced to sell their product to these brokers who in return sell the crop to the prospective traders and exporters.

- typhoons that occur only a few times during the planting season also affect production. Farms heavily affected by typhoons require rehabilitation. However, no company is willing to take the risk of helping the farmers to acquire the necessary quantity they need at the end. Likewise, typhoons decrease 10-20% of the production due to delays in drying time of the raw material.

Low production is the main problem right now of the KSPA and neighboring farm areas. Our production output for the past two years had a dramatic fall to about only 60% since 1999.

Actions to be taken

In the late nineties, it wasn't known that Zamboanga produced majority of the seaweed in the Philippines. But it was regarded as the seaweed capital of the country. The present problems need a closer look from the people in the industry like the farmers, traders, exporters, processors, government and non-government sectors. A cohesive effort among these key players to solve the problems is thus needed to sustain the seaweed industry. However, I would like to stress the following points:

Rehabilitation. The farms need rehabilitation especially those that are destroyed by diseases, typhoons and sudden drop of price. We do not brag that we can still do this on our own as in the past. We do not also beg for we are not used to begging. But we would like to awaken the minds of the people in the government and non-government institutions to help us not just for the benefit of ourselves but also for the economy of our country as a whole.

Strong government support. I would like to refer this issue to the government sector. We are glad to know that our present administration has several projects under its wing to support the livelihood of the people in our country. The agricultural and fishery sector program of the present administration is most welcome, however, proper implementation is to be done so that the appropriate beneficiaries of the program will be the recipients of the programs.

Strong support from the traders/exporters and processors. Traders, exporters and processors must invest not only in the exportation or processing of the raw material, but also in the production of the seaweed to ensure a continuous and stable supply of good quality raw material. Without good quality raw material, nothing can be processed into carrageenan.

Conclusion

Lastly, we are all concerned with the seaweed industry and after relaying to you my experience, I hope I was able to enlighten your thoughts. I know we share the same sentiments and whatever happens to our seaweed industry, we will all be affected. Now, I would like to tell you that what I had started was not for my own advantage nor the advantage of our company, but it was intended to provide livelihood to the once less fortunate but now much improved Filipinos, economically and socially.

The quest in seaweed farming continues as there are new challenges in the horizon. What lies ahead of the industry depends much on you and me as we work together hand-in-hand.

Status of *Kappaphycus* and *Caulerpa* Farming in Palawan

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Seaweed farming is an established industry in the Philippines. Most of the seaweed produced in the Philippines come from mariculture or farming. The three major producing areas are Regions 4, 9, and the Autonomous Region for Muslim Mindanao (ARMM).

In the Southern Tagalog Region (Region 4), the main farming areas are the provinces of Palawan, Quezon and Batangas. Palawan has the highest production in the region which is about 138,950 mt (Provincial Agriculture Office, PAO 2000), hence, the bulk of seaweed harvest came from the Province. Palawan has a total land area of 14,893.3 square kilometers. Its coastline stretches 2,000 km from north to south and is composed of 23 municipalities and one city. Twenty municipalities are engaged in seaweed farming (PAO 2000).

Farming

In 1978, seaweed farming was introduced in Green Island, Roxas, Palawan by the Marine Colloids, Philippines. In 1979, seaweed farming using the Tawi Tawi technology was adopted in the municipality of Balabac. Being a profitable business, seaweed farming became very popular in the area many "Palawenyos" adopted seaweed farming as their main source of livelihood.

Production areas

In Palawan, the Provincial Technical Working Group on Seaweeds conducted a study on seaweed farming. The municipalities were then classified based on the climatic condition of the area:

Class A (year round) - Agutaya, Cuyo Island (Cuyo and Magsaysay), Cagayancillo, Balabac, and Calamianes Group of Island.

Class B (year round but need to transfer from one area to another) - Dumaran, Roxas and Taytay.

Class C (seasonal planting) - El Nido, San Vicente, Aborlan, Narra, Bataraza, Rizal and Quezon.

Seaweed species

There are several seaweed species found in the province. Among the common species with economic importance are *Eucheuma, Caulerpa, Gracilaria* and *Sargassum.* These species are collected from the wild. *Kappaphycus alvarezii* and *Eucheuma spinosum* are the major species cultured in marine waters. Some seaweed farmers culture *Caulerpa* sp.

Culture methods

There are basically two culture methods for *Eucheuma* used by farmers. Farmers have tried some modifications of the two methods. In Palawan, four culture methods for seaweed farming are used:

Fixed monoline method - This method requires low investment from farmers. It can be installed easily in shallow portions of the coastal areas. Many farmers adopt this method because of its practicality.

Floating vertical monoline method - This method is done in deep waters using bamboos which are tied together. Floating materials like styrofoam serve as bouys. The end of the lines are arranged in parallel position and tied to support lines at the bottom that are anchored in rocks.

Multiple longline method - This method is used in deep waters at 10 meters and above. The lines are installed in areas with moderate to strong water movement.

For *Caulerpa* sp., the rice planting method is used. The species is planted in rows. The culture of *Caulerpa* is also known as the 'sea garden'. The farming area is surrounded by fences.

Management

In farming seaweeds, it is important to secure good quality seedling. Farmers usually produce their seedlings in nurseries. Sometimes, seaweeds are sourced from nearby nurseries or are provided by government agencies like the Provincial Government or the Bureau of Fisheries and Aquatic Resources (BFAR). Some municipalities in Palawan like Quezon and Coron have established seaweed nurseries. *Eucheuma* seedlings are sold at PhP 5 to 12 /kg.

In farm maintenance, lines are checked regularly. Unhealthy seedlings are replaced in cultured lines. Farmers see if ties-ties are tied up properly. Unwanted grazers are removed from the area. The seaweeds are allowed to grow from 45-60 days after planting. In Palawan, there are about 3-4 cropping periods/year for seaweed farming.

Harvesting

After two months culture period, seaweeds (*Eucheuma)* are harvested by 3 to 4 people. Seaweeds tied lines are harvested and placed in rattan baskets. Each rattan basket can accommodate 25 kg of seaweeds. The seaweeds are brought to the boat and later in platforms for drying.

Health management

Health management in seaweed farms is primarily done with proper site, species selection and farm maintenance.

Areas with low salinity are not recommended for *Eucheuma* culture. Healthy and young seedlings are planted to obtain good growth. Undesirable materials and seedlings which look diseased are removed. When a disease spreads in a farm, complete harvesting of seaweed is immediately done.

Post-harvest management

After harvesting, *Eucheuma* is cleaned by washing and removing foreign materials. Seaweeds are then placed in platforms for drying. Drying is done for 2-3 days under the sun. Seaweeds are usually covered with coconut leaves or sacks. When dried, seaweeds are placed in sacks, weighed, stored in warehouses, and sold to buyers.

Marketing

Seaweed is one of the export winners of the country. There are many seaweed traders/buyers in the country. In the province of Palawan, the common practice is from farmer/producer through traders (local traders/viajeros) to exporter/processors. The marketing of seaweeds is channeled to several buyers before it reaches the processors. The price of dried *Eucheuma* ranges from PhP 20-30/kg while *Caulerpa,* which is sold fresh, is at PhP 70-80/kg.

Status of Seaweed Farming in Region 6

Roed Shane T. Hablo
BFAR Region 6
Molo, Iloilo City, Philippines

Seaweed Production

The annual average production of seaweed in Region 6 from 1995 to 2000 is shown below:

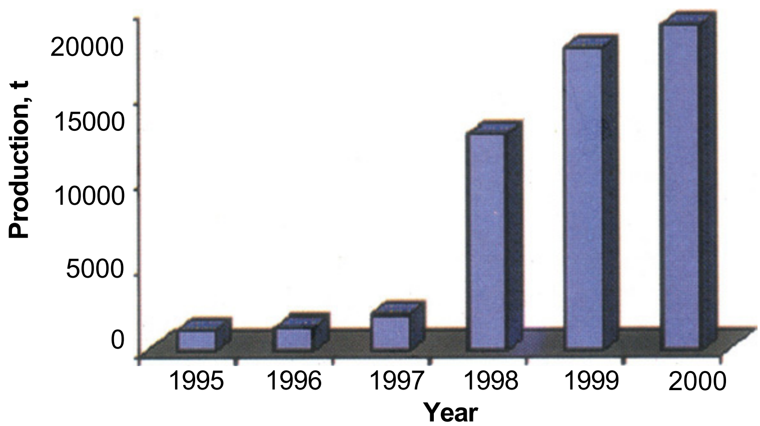

Figure 1. Seaweed production from 1995 - 2000
Source: Philippine Fisheries Profile

The increase in production was due to the provision of technical assistance, extension services and information dissemination which created public awareness towards the use of modern technology on seaweed farming and market demand.

BFAR assisted nursery/demo farms

- Seaweed Nursery Farm - Maniguin Island, Culasi, Antique
- Seaweed Demo Farm - Pulo Piña, Concepcion, Iloilo
- Seaweed Demo Farm - Nadulao Island, San Lorenzo, Guimaras

The demo projects and nursery farms are managed and maintained by the fisherfolk association in the area.

Table 1. Existing seaweed growers association in Region 6

Name of farmer cooperative	**Species cultured**	**Farm size**	**Culture method**	**Disease/s & frequency of occurrence**
Maniguin Seaweed Growers Association Maniguin, Culasi, Antique	*Kappaphycus alvarezii*	50 ha.	Hanging-monoline	"Ice-ice", start of the rainy season
Municipality of Carles	*Kappaphycus alvarezii*	1/4 ha.	Hanging-monoline	"Ice-ice", start of the rainy season
Bat-os Small Fishermen's Association, Pulo Piña Concepcion, Iloilo	*Eucheuma* sp.	1/4 ha.	Hanging-monoline	"Ice-ice", start of the rainy season
Nadulao Is. Seaweed Growers Association Tando, Nueva Valencia, Guimaras	*Eucheuma* sp.	3 ha.	Hanging-monoline	"Ice-ice", start of the rainy season
Carles Seaweed Growers Association, Carles, Iloilo	*Kappaphycus alvarezii*	10 ha	Hanging-monoline	"Ice-ice", start of the rainy season

Status of Seaweed Farming in Region 9

Halpi H. Kalbi
BFAR Region 9
Zamboanga City, Philippines

Before 1970, *Eucheuma* locally known as "agar-agar" was found abundant in the Philippines, particularly in the province of Tawi-Tawi, Sulu and Zamboanga City. It became a source of livelihood among the people living in the coastal areas especially in Region 9 and the Autonomous Region for Muslim Mindanao (ARMM). However, constant gathering/harvesting and no proper conservation and propagation, resulted to the depletion of the seaweed resources.

Knowing the impact of the shortage of supply of seaweeds, our government conducted research studies, training programs on seaweed farming and established seaweed Demo Farms in Luuk Bongao, Sacol Island, Zamboanga City; Tapaan Island, Siasi Sulu; and Simunul, Tawi-Tawi for demonstration and seaweed production. Through that initiative, *Eucheuma* farming was successfully promoted in 1973 wherein production dramatically increased.

It is surprising to note that it was the local producers of Zambaonga City, Sulu and Tawi-Tawi who themselves modified the introduction of the costly net method to the more economical floating monoline method of farming. They discovered the giant-sized seaweed and fast growing varieties of *Eucheuma cottonii* in the area and named it "tambalang".

Region 9 is considered the number two seaweed producer in the country. In 1996, the region contributed 107,541 mt or 91% of the total aquaculture production. The region has recorded an annual production of 138,765 mt.

Seaweed farming provides an important source of livelihood to more than hundreds of thousands of families living in the coastal areas who are directly involved in the production as farmers or as entrepreneurs. Presently, only 6,091 ha are utilized for production out of 15,995.8 has. potential areas. The development of the potential areas would mean an increase in production.

Tables 1-4 show important data for the seaweed industry. Total production area 6,091 ha: Zamboanga City (ZC), 2,959; Zamboanga del Norte (ZdN), 520; Zamboanga del Sur (ZdS), 2,202; and Basilan Province (Bas), 415.

Potential production area is 15,995.8 ha: Zamboanga City, 2,470; Zamboanga del Norte, 325; Zamboanga del Sur, 13,180; and Basilan Province, 20.8.

Table 1. Number of seaweed key players by province

Players	ZC	ZdS	ZdN	Bas.	Total
Farmers	4,314	1,028	493	317	6,052
Traders	13	3	11	5	32
Processors	3	0	0	0	3

Methods of farming

- Floating monoline
- Bamboo raft

Species of *Eucheuma* planted:

- *Kappaphycus alvarezii* - 90%
- sacol variety ("*cottonii*") - 8%
- *Eucheuma denticulatum* (*spinosum*) - 2%

Table 2. Regional Seaweed Production (mt)

Year	ZdS	ZC	Basilan	ZdN	Total
	7,925	79,128	349		87,402
1995	8,262	85,033	541		93,836
	2,340	2,340	5,963	512	8,815
1996	8,346	95,260	435	3,500	107,541
	9,569	120,818	368	8,011	138,765
1997	11,467	79,947	423	12,131	104,408

Source: Bureau of Agriculture Statistics-9 (BAS)

Table 3. Exported Dried Seaweed (Jan-Dec 2000)

Species	Value ($)	Volume	Importing Country
Eucheuma cottonii	1,787,450	2,123,526	France
dried seaweed	1,335,810	2,182,147	Hong Kong
	878,100	1,386,898	China
	1,843,180	2,264,520	Korea
	166,800	443,000	Taiwan
	480	25	Taipei
	86,000	200,000	Spain
	55,600	120,000	Brazil
	16,400	20,002	Japan
	55,245	137,000	Malaysia
Total	**6,228,065**	**8,877,118**	
alkali-treated	24,190	19,000	Japan
seaweeds	567,558	161,320	Korea
	98,000	35,000	France
	148,460	133,000	China
	6,000	3,000	Japan
Total	**696,356**	**351,320**	

Source: BFAR 9

Table 4. Number of Seaweed Industry/ Organizations:

Organization	ZC	ZdS	ZdN	Bas.	Total
Development Council	1	1	0	0	2
Federation	0	1	0	1	2
Association Cooperative	11	25	9	45	90

Organization and local partners in the development of seaweed industry

National Agencies

Department of Science and Technology
Department of Agriculture
Department of Trade and Industry
Bureau of Fisheries and Aquatic Resources Central Office and Regional Office No. 9
Regional Fisheries Training Center
Department of Environment and Natural Resources

Local Government

Provincial Agriculture Office
Office of the City Agriculture

Private Sector/Academe

Growth with Equity in Mindanao Program
Zamboanga State College of Marine Science and Technology
Western Mindanao Seaweed Industry Development Foundation

Issues and Concerns affecting the seaweed industry of the region

Problems that affect the seaweed industry in the region are: scarcity of quality seedlings; high cost of inputs/planting materials and transport; rampant practice of harvesting immature plants; lack of seaweed processing plants for processing carrageenan and other post harvest facilities; and poor peace and order situation. The industry also needs guidelines to prevent contamination from toxic wastes, identify the moisture content of dried seaweeds, and methods to combat and prevent seaweed diseases.

Seaweed Farming in the Sulu Archipelago

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After the successful culture of *Eucheuma* in Siasi, Sulu by the group of the late Dr. Maxwell Doty, Sulu and Tawi-Tawi became the first provinces to adopt and innovate on the technology. Seaweed farming in the Sulu archipelago became a major livelihood second to fishing especially among the coastal dwellers. Seaweed farming improved not only the living conditions of the populace but also in part helped solve the insurgency problem. However, until today some farmers still remain poor despite the economic benefits they obtain from the industry. This may be due to the different problems that beset the industry, which affect them economically. This paper deals on seaweed farming in the Sulu Archipelago especially Tawi-Tawi, its problems and its impact on the environment.

Seaweed farming

The fixed off-bottom and floating methods are the most common methods used in seaweed farming in the Sulu Archipelago. An innovation of the floating method, the "palabad", is used in Sitangkai, where only one end of the line is tied to a stake leaving the other end free. The free end goes with the current. This is usually employed in deeper areas or in channels (river, harbor, or strait).

Farm size vary from 0.25 ha to over a hectare. The frequency of planting also varies. Some farmers plant 4 to 6 times a year while others plant 3 to 4 times a year. Most of the time, farming is done depending on the availability of funds (capital), seedling materials or people who could tend the farm. Planting is usually suspended whenever there is an occurrence of "ice-ice" disease. Since farmers already know the probable time when the disease occurs, they stop planting one month before the onset of the disease and resume planting a month after the disease disappears. This is done to make sure that the area is "clean".

Plants are usually harvested 20 to 45 days after planting. Farmers revealed that harvesting of plants depends on the demand of seaweed raw materials and sometimes dictated by buyers. Sometimes buyers prod them to harvest their plants even if their plants are newly planted because of the demand in the market. Farmers, however, say that it is not advisable to let the plants stay in the farm for more than 60 days because the plants become heavy that the thalli can no longer hold its weight. The thalli are brittle and easily break even with the slightest movement of the water. They also claim that even if they prolong their culture, their weight would no longer increase sizably. Furthermore, they stress that as soon as the plants reach optimum size, they harvest them immediately to avoid the occurence of "ice-ice" disease any time.

Farmers intimated that the "giant" variety are usually harvested 20 days after planting because this "giant" variety grows very fast, allowing it to acquire a large biomass immediately.

Seaweed farming is a family enterprise where almost all members of the family, including the children, are involved.

Seaweed Production

The introduction of seaweed fanning in the early seventies provided much economic benefits that it became the third ranking fishery export of the country. From the south, seaweed farming rapidly spread all over the country. At present the Seaweed Industry Association of the Philippines (SIAP) grouped the seaweed-producing areas into clusters, with Sulu and Tawi-Tawi belonging to cluster 5.

Among the different regions, the Autonomous Region for Muslim Mindanao (ARMM), where Sulu and Tawi-Tawi belong, accounts for 52% of the total seaweed production in the year 2000 (Figure 1). Practically, the whole province of Sulu and Tawi-Tawi is involved in seaweed farming. Areas in Sulu which are engaged in the industry are: Maimbong, Panglima Tahil, Indanan, Siasi, Pandami, Patikul, Pata, Tongkil and Tapul. In Tawi-Tawi, 8 municipalities are involved in farming wherein Sitangkai produced the most amount of seaweeds (Table 1). Data from the Provincial Agricultural Office of Tawi-Tawi indicated an increasing seaweed production from 50,034 t in 1992 and 240,420 t in 2000. An increasing number of farmers from 9,375 in 1992 to 21,000 in 2000 were involved in the activity. There were 5,054 ha planted with seaweeds in 1992 and this increased to 26,718 ha in 2000. The Provincial Agriculture Office of Tawi-Tawi reported an increasing trend in seaweed production for Tawi-Tawi from 1992 to 1999, however, production remained almost constant for 1999 and 2000. One reason is that the area planted with seaweeds did not increase compared with the previous years, and that there was almost the same number of farmers who were engaged in farming (Table 2).

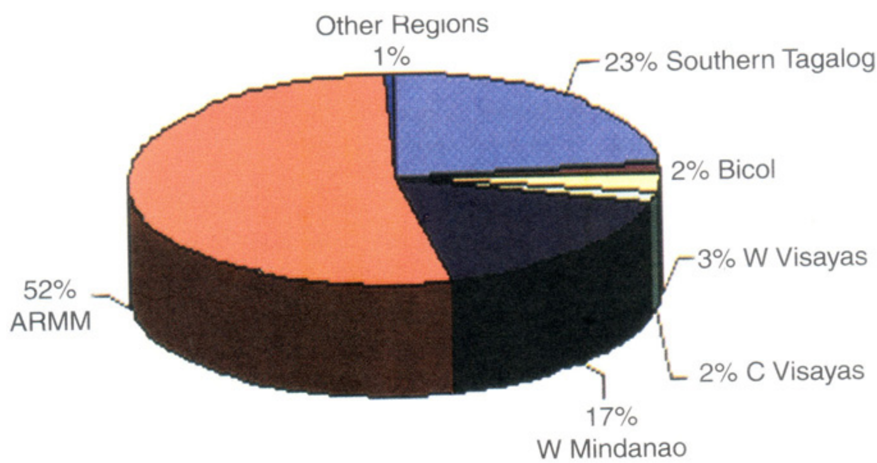

Figure 1. Percentage seaweed production by Region (Year 2000).
Source: Bureau of Agricultural Statistics.

Table 1. Area of seaweed farms and production by municipality, Tawi-Tawi (2000)

Municipality	Area Planted (ha)	Production (t)*	Potential Area (ha)	Number of Farmers
Sitangkai	6,739	59,216	375	4000
Panglima Sugala	4,279	38,798		3,556
Tandubas	3,964	35,963		3,203
South Ubian	3,140	28,547		2,203
Languyan	2,956	26,891	4,520	2,491
Simunul	2,564	23,363		2,049
Sapa-Sapa	2,090	18,810	1,118	2,491
Bongao	1,068	18,810		1,507
Total	**26,800**	**241,200**	**6,013**	**21,500**

*Average Production per hectare is 9 t
Source: Tawi-Tawi Provincial Agriculture Office (PAO), 2000

Table 2. Trend of seaweeds production (t wet-weight equivalent) in some provinces (1993-2000)

Province	1993	1994	1995	1996	1997	1998	1999	2000
Tawi-Tawi	103,867	123,047	164,763	166,200	181,336	186,293	189,192	168,398
Sulu	168,528	167,283	178,996	168,860	173,729	173,223	168,265	157,392
Palawan	56,439	102,150	102,649	178,910	163,495	141,301	103,386	139,950
Zamboanga City	15,063	45,140	79,128	85,139	82,151	95,260	98,131	81,947
Antique	1,714	1,653	1,255	1,282	1,843	12,027	17,222	18,831
Zamboanga del Sur	8,762	8,269	7,925	8,165	7,921	8,346	9,569	12,131
Zamboanga del Norte	0	0	0	0	0	5,850	8,010	11,907
Sorsogon *(Gracilaria)*	1,144	2,678	10,813	8,845	2,062	3,069	3,415	2,570
Camarines Norte	0	0	0	0	715	3,558	5,018	5,012
Mindoro Occidental	1,541	1,818	1,052	1,346	1,324	1,402	1,333	1,345
Surigao del Sur	624	493	391	440	556	565	739	1,178

Source: Bureau of Agricultural Statistics

life through seaweed farming. However, the fishing industry was severely affected because many fishermen shifted to seaweed farming.

In terms of ecological impacts, Trono (1993) claimed that in the construction of the support system for the farm, the associated ecosystems like the mangroves, coral reefs and seagrasses are affected. Cutting of tall seagrasses, removal of seaweed thalli and rocks are necessary. Initially, the stakes used are mangrove posts because they are stronger and lasts longer than other wooden stakes when submerged in seawater. In the process of planting and harvesting, trampling on the farm bottom, which can include transplanting on corals may also occur. However, the ecological benefits derived from farming far outweighs these detrimental effects (Trono 1993).

In fact Doty (1973) indicated that seaweeds culture is an effective conservation measure since this stops the practice of wild stock harvesting which do not mean pruning but tearing away the basal discs of the *Eucheuma* thereby disturbing the substrate. Harvesting from natural stocks is destructive, because this does not leave any material for regeneration, eventually extirpating the species from the area. This practice leads to ecological repercussions on some species, which are totally or partly dependent on the seaweeds and on the overall ecological function they perform.

The introduction of seaweed farming in resource depleted areas like reef flats results in the enhancement of their environmental conditions (Trono 1993, Phillips 1990). Seaweeds, as primary producers, enhance the organic production and serve as food to various herbivores like siganids and sea urchins, which are likewise food of some animals in the higher level of the food chain. Hence, productivity of the reef flat improves (Trono 1993). The presence of a large biomass of seaweeds results in habitat enhancement by providing shade, cover and attachment surfaces to associated marine plants and animals. Large seaweed farms may also help protect other more sensitive culture species and systems such as mussel or scallop culture (Phillips 1990). No study has yet been made on the amount of contribution of large seaweed farms to carbon sequestration in the atmosphere.

Seaweed farms also provide residence and food to some micrograzers like sea urchins, *Tripneustes gratilla,* which arrive in planktonic form and settle on the seaweed (Doty 1987). The second type of grazers is the synaptid holothurian, *Ophiodesma spectabilis,* that come as net plankters. In the process, they graze off the thalli of the seaweed thereby affecting their growth or severing them. To seaweed farmers, they are treated as pests, but they perform a role in enhancing the biodiversity of the area. Doty (1987) likewise noted that macrograzers like the long spined sea urchin, *Diadema sitosum,* rabbit fishes, puffer fishes are co-existing with the seaweed farms since they are the major grazers. But the largest grazer of all is the green turtle, *Chelonia mydas.* The effects of feeding especially in numbers is definitely devastating to the farmer but the farms serve as bountiful grazing ground of this threatened species. We have heard some accounts that green turtles forage in the seaweed farms of Tawi-Tawi and this was confirmed by one of the satellite tracking experiments wherein one turtle was recorded to have gone from Turtle Islands to Tandubas, Tawi-Tawi.

Seaweeds have also the special property to sequester some pollutants in the water medium as shown by Troell et al. (1999) when they used seaweed for removing nutrients from intensive mariculture. They are also known to absorb low levels of lead, mercury, arsenic, magnesium as shown in the analysis of the composition of carrageenan and seaweed flour.

In terms of its deleterious effects, Trono (1993) stated that since farms are now located in far away reef flats, settlements have now sprouted in these areas. This would then contribute problem of domestic wastes. However, he noted that due to strong currents prevailing in these areas, these wastes especially organic ones do not accumulate in the reefs as in the Danajon Barrier Reef in Bohol. In the municipality of Sitangkai, the farms are already located on the reef flats almost at the boundary between Semporna, Sabah, Malaysia and Tawi-Tawi because of the very good growth rates of seaweeds in these areas. Seaweed farmers from Sulu and even from Basilan have settled in what the natives call "pondohan" (personal observation). Initially, these were just temporary shelters to watch over their farms during the culture period. However, it has now evolved into clusters of five or more houses for every "pondohan". Each "pondohan", usually led by the head of the clan or large family, has its own system of governance and means of securing their farms and their property. In these areas, where they are left to fend for themselves, illegal fishing activities like dynamite and cyanide fishing are common practices. This is likewise true to the outlying reefs of Balabac Municipality in Mangsi Islands (personal observation). However, it was also observed that in some of the "pondohans" in Sitangkai, the farmers also grow out *Tridacna* species within their farms. *Tridacna* species are listed in CITES as threatened and if they can grow this out to maturity to a point that it has spawned at least once before eating the meat or selling the shell to Sitangkai traders, they shall have contributed to its conservation. It has also been observed that because of the prosperity that seaweed farming has generated, communities can now afford to build concrete houses and "pantans" or drying areas for the seaweeds. Unfortunately, they quarry coral stones and rubbles as filling or reclamation materials for the construction of their houses and drying areas. This is widely practiced in Sitangkai and in Tandubas areas (personal observation).

Phillips (1990) claims that since seaweeds culture system relies mostly on natural nutrient supply, its eventual depletion may occur. Though this has not yet been well studied, the use of nutrients through the macroalgae rather than phytoplankton food chains could disturb the natural nutrient recycling process and secondary productivity. Phillips (1990) further says that since high density culture areas require large amounts of nutrients, this will affect the long term viability of seaweed farming itself. Use of synthetic fertilizers to supplement natural sources of nutrients may not be a practical option.

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Status of Seaweed Industry in the Autonomous Region for Muslim Mindanao

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This paper briefly describes the *Kappaphycus/Eucheuma* production in the Autonomous Region for Muslim Mindanao (ARMM). Likewise, it reports the key production areas in the region (Figures 1-6). Three methods of culturing the seaweed are practiced by the fisherfolk: (1) bottom stake, (2) bamboo raft, and (3) floating monoline. Culture of seaweed is year-round at 45-60 day culture period, with 4-5 harvests/year. 'Seedling' usually weighs 200-300 g. An average of 8 t (fwt) of seaweed is harvested at 0.25 ha (32 t/ha). The 'suki' system of selling/buying dried seaweed is practiced in the region.

Despite the success story of the seaweed industry of this region, it is still faced with problems such as: control of traders in the purchase of seaweed; lack of technical know-how in seaweed processing; inadequate financial assistance from the government; deterioration of the quality of seedlings; absence of zoning in some areas; losses due to theft and pilferage; inadequate drying facilities and warehouse; and natural calamities.

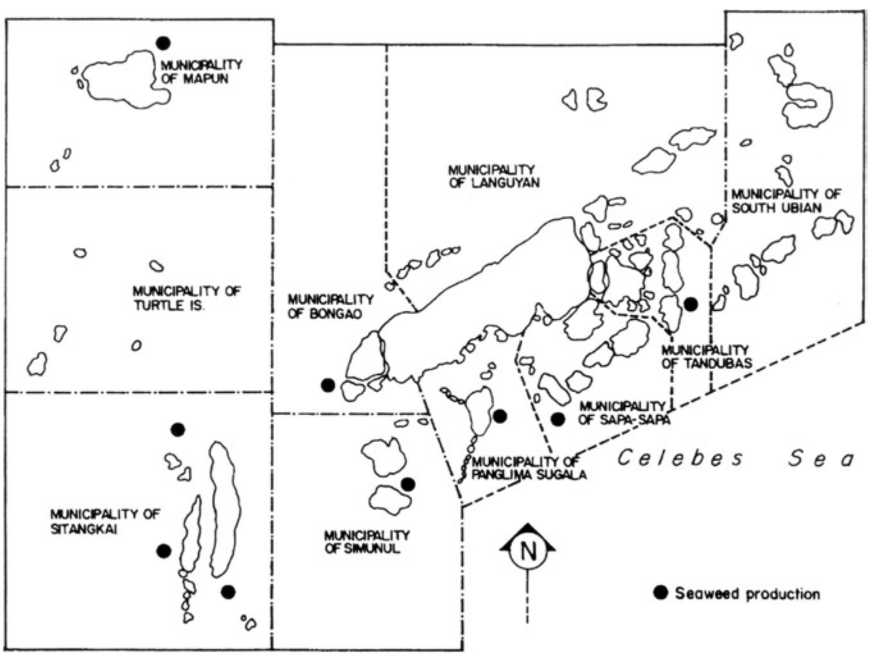

Figure 1. Map of Tawi - Tawi

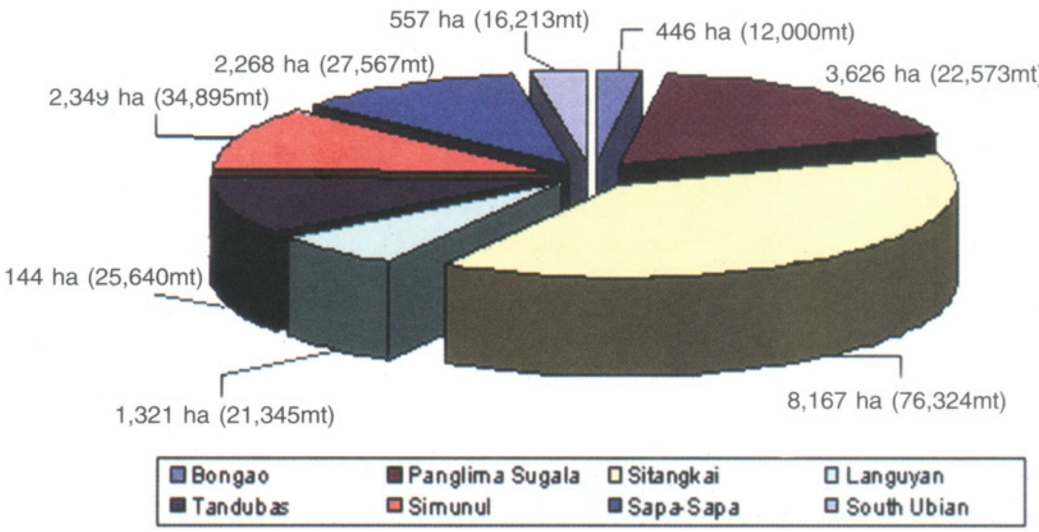

Figure 2. Seaweed production/area in Tawi - Tawi year 2000

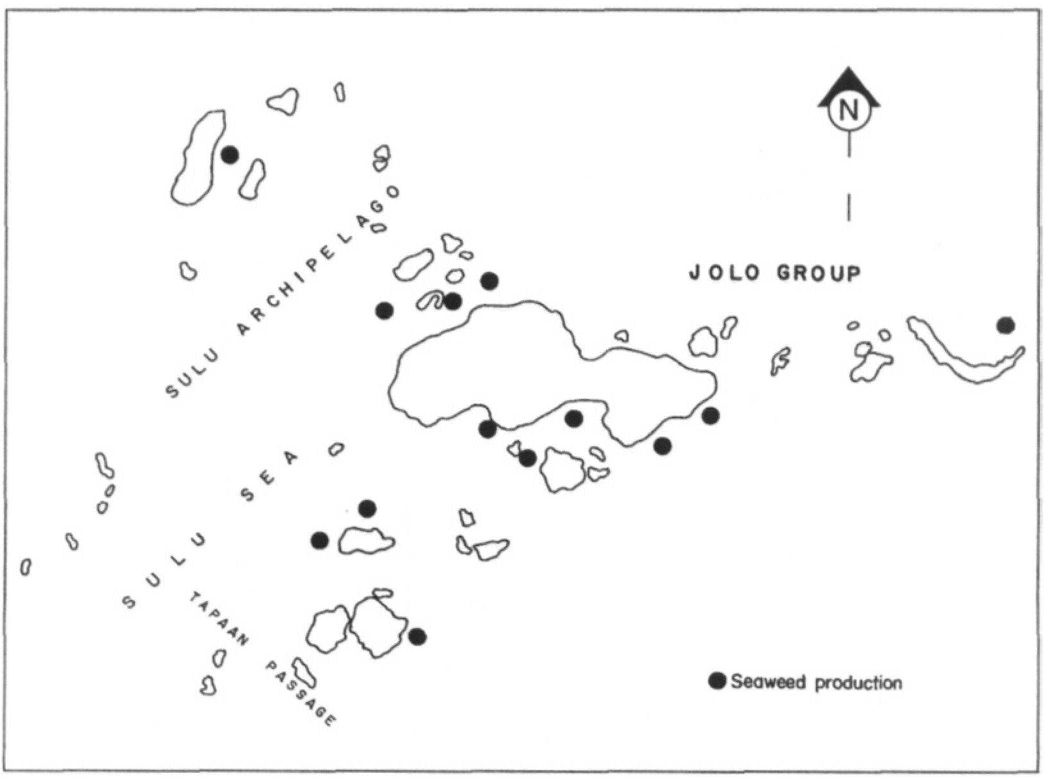

Figure 3. Map of Sulu province

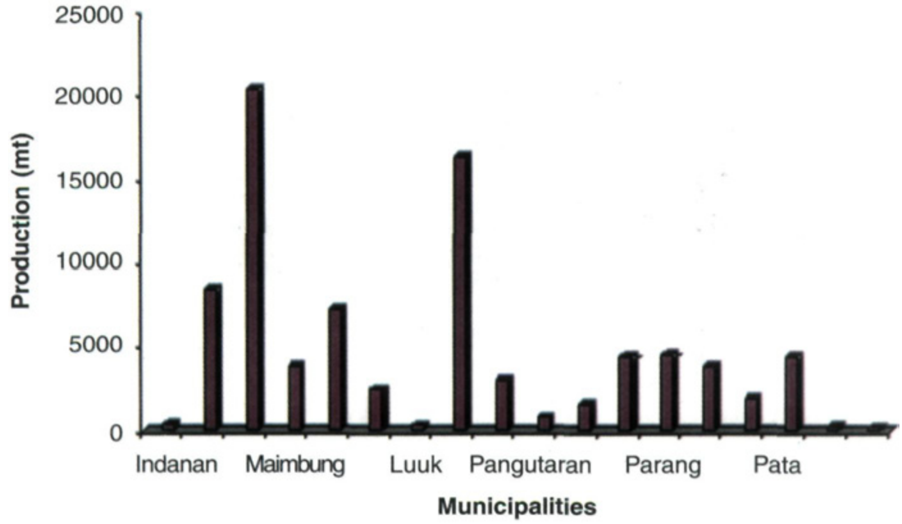

Figure 4. Seaweed production (mt) in Sulu year 2000

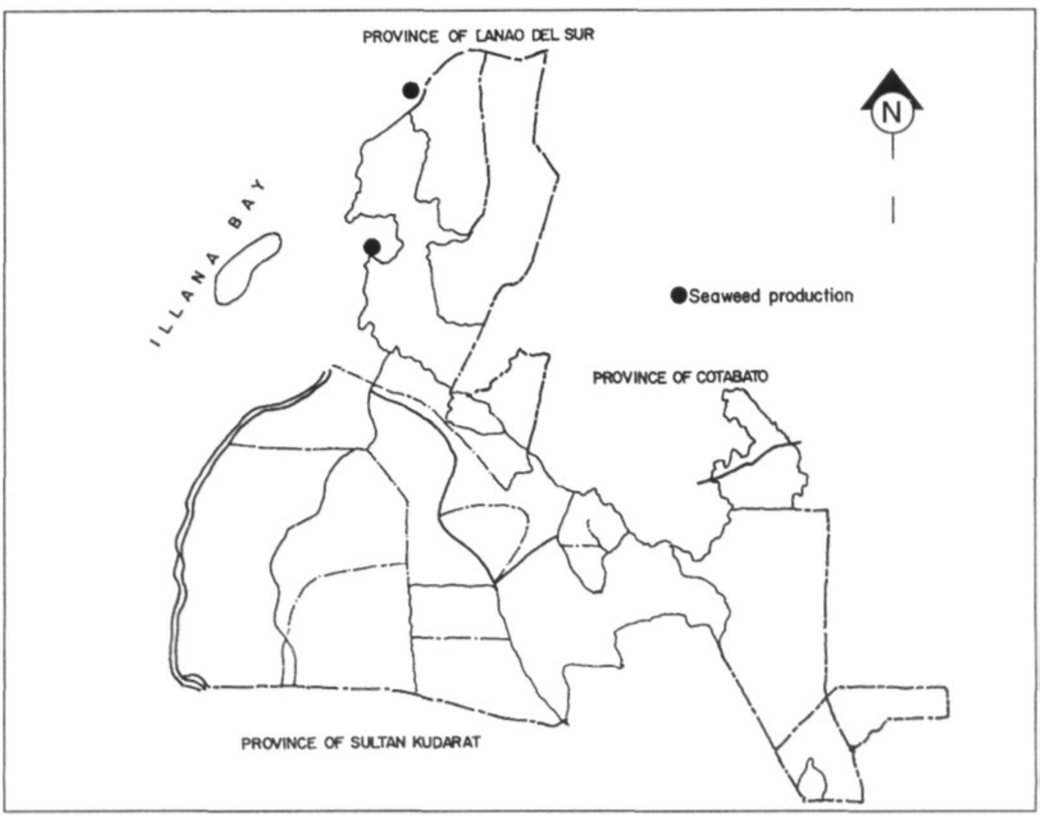

Figure 5. Map of Maguindanao province

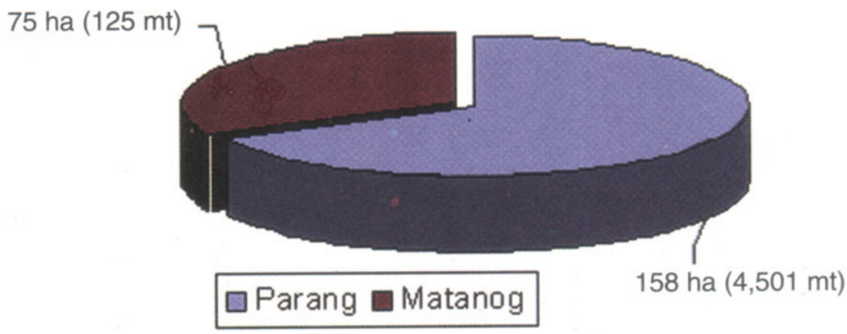

Figure 6. Seaweed production/area in Maguindanao year 2000

National Seaweed Program

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One of the priority thrusts of the Government under the Agrikulturang Makamasa Program for Fisheries is the development, utilization and management of the seaweed resource in the Philippines. Seaweed is one of the major fisheries commodities targeted to enhance the country's economic stability. The importance of seaweed can be seen in two perspectives, that of ecological and economic importance. In terms of ecological importance, seaweed is one of the primary producers in the marine ecosystem and it also serves as habitat and breeding ground for many marine organisms. Economically, seaweed is an important source of human food and raw materials for phycocolloid production, such as carrageenan, agar and algin. Several reports and studies revealed that seaweeds are also used as fodder, fertilizer and for waste water treatment (i.e. biofiltration, bioremediation). In totality, the seaweed resource contributes substantially to the country's fisheries production, trade and employment.

To support and achieve the Government's vision and mission in the new millennium, the Department of Agriculture (DA) through the Bureau of Fisheries and Aquatic Resources (BFAR) conceived and implemented a five-year (1996-2000) Seaweed Development Program (SDP) (Figure 1). The BFAR recognized the many uses and great contributions of seaweed in Philippine economy and would like to sustain the present position of *Kappaphycus/Eucheuma* and its natural product in the international market The responsibilities and expectations of BFAR became bigger when it was elevated again to a line agency in 1998 pursuant to Republic Act 8550 otherwise known as the "Philippine Fisheries Code of 1998". Thus, SDP was conceptualized to implement a well coordinated industry with responsive projects and activities on seaweeds both at the national and regional levels. The Program is designed to strengthen BFAR meeting the needs and challenges that beset the Philippines seaweed industry.

Objectives

The long range objective of SDP is to enhance the BFAR R&D projects/activities on seaweed for its further development to be able to address the issues and concerns of the seaweed industry.

The short range objectives are to put all seaweed related projects and activities under one umbrella, to establish linkages with the other sectors of the industry, and to facilitate transfer of technologies to end users, particularly the small seaweed farmers, processors and entrepreneurs.

Opportunities

The seaweed industry is now considered the sunrise industry because of its strengths and many opportunities for the Philippines. In the new millennium, it is expected that the Philippines will continue its leading position in the international market of *Kappaphycus* and carrageenan

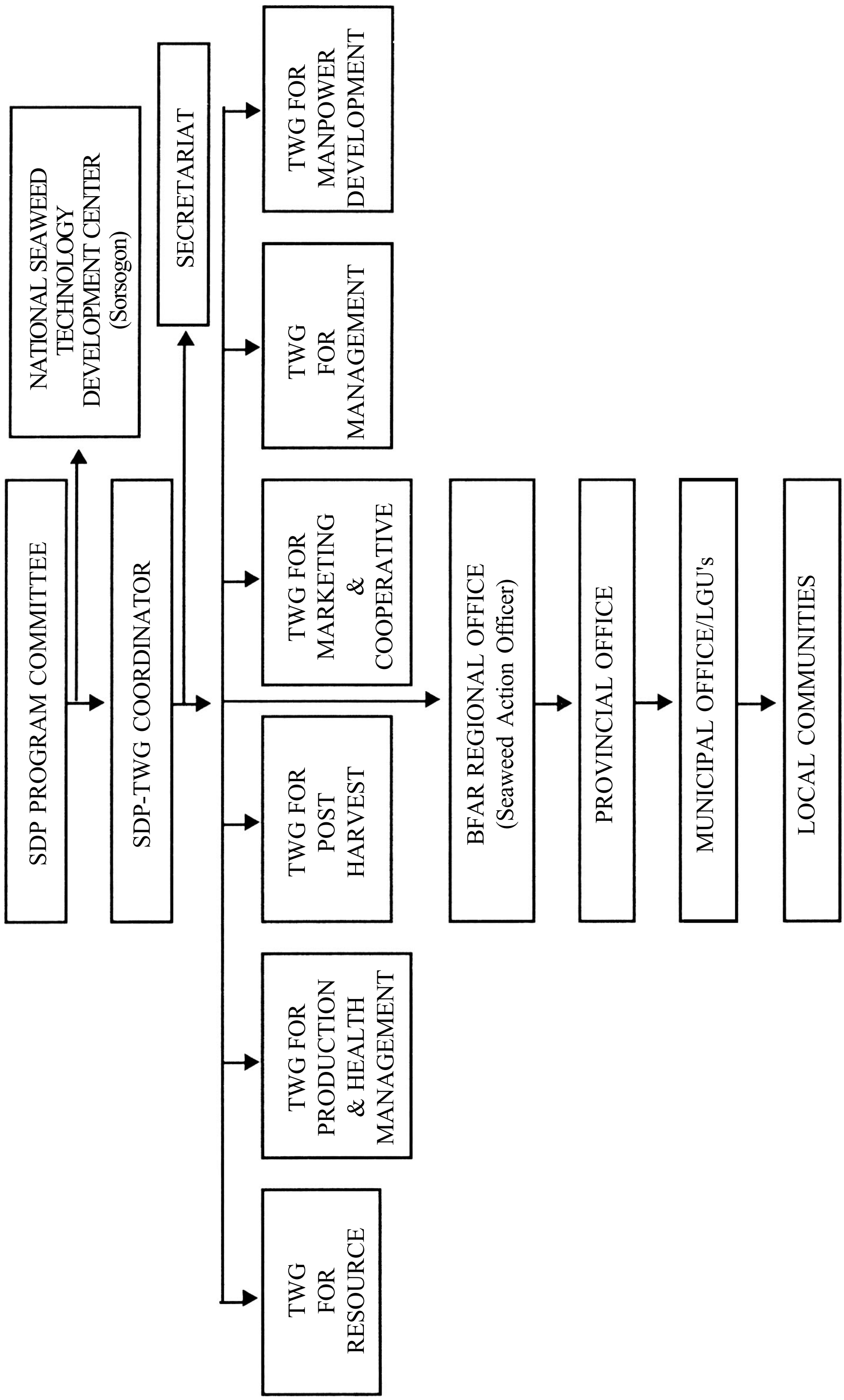

Figure 1. Organizational structure for the implementation of the Seaweeds Development Program (SDP)

through: expansion of production areas; big demand for quality seedlings; big demand for raw materials and carrageenan in the international market; more potential seaweeds with economic uses; revitalized Seaweed Industry Association of the Philippines (SIAP); and stronger linkage and collaboration of all sectors of the industry.

Issues and concerns

The BFAR is very much aware that together with the potentials and many opportunities are the problems and concerns of the seaweed industry. The major problems and concerns that need to be addressed are the following: deteriorating quality of the seedlings/stocks; declining farm productivity; poor quality of dried raw materials; seaweed diseases; substandard post-harvest handling and drying techniques; unstable buying and pricing practices; lack of credit assistance to the seaweed farmers; and lack of regulation on seaweed culture and management.

Program framework

To achieve the goals of the SDP and address the problems that beset the seaweed industry, BFAR came up with a program framework which consists of the following components:

A. Research and Development

1. Resources
- assessment and biological studies

2. Production
- laboratory and field researches
- development and improvement of farming technologies
- establishment of techno-demo farms and seaweed nurseries
- site assessment potential for seaweed farming
- health management of seaweeds

3. Processing
- biotechnology
- production of phycocolloids
- improvement of seaweed processing plant/facilities
- improvement of post-harvest technology
- development of value-added products

4. Marketing
- promotion of market matching
- assistance to private sector in credit availment

B. Management Component

- Resource management schemes
- Information and educational campaign
- Review of laws and regulations

C. Manpower Development

- Inventory of national capabilities
- Training of manpower

D. Institutional Development

- Improvement of BEAR facilities
- Establishment of satellite seaweeds R&D Centers

Highlights of accomplishment, CY 1996-2000

Creation of the National Seaweed Technology and Development Center (NSTDC) in Cabid-an, Sorsogon. The Center is tasked to undertake studies on biology, production ecology, processing and management of seaweed resources. The Center has established demo farms in 4 coastal areas in Sorsogon. The Center also developed value-added product such as fresh salad, pickled seaweeds and noodles. The agar derived from *Gracilaria* spp. was used as additive for macaroons, agar pie, jelly, jam, ice candy, fish embutido and tilapia sausages/frankfurter. The Center provides extension services on seaweed farming and processing to various cooperatives/association in Camarines Sur and rendered technical assistance to clienteles, such as the Local Government Units (LGUs), seaweed farmers, researchers and students.

Establishment of seaweed nurseries and techno-demo farms in selected coastal areas in the Philippines. The BFAR Regional Offices identified 66 possible sites for the establishment of seaweed nurseries nationwide. The nurseries serve as source of quality seedlings for distribution in nearby coastal areas/municipalities.

Assessment of seaweed resources in selected coastal areas has been done to determine the phenology of the sites. To date, the BFAR Seaweed Research Team conducted detailed assessment in Southern Leyte, Southern Palawan and CARAGA waters. Rapid resource assessment was done in selected provinces/regions, such as Regions 1, 2, 4, 5, 6, 7, 8, 9, 10 and 13. Various seaweeds were collected and identified during the assessment work. The economically important seaweeds recorded include *Acanthopora specifera, Caulerpa lentillifera, Codium* spp., *Gelidiella acerosa, Gracilaria* spp., *Halimeda* spp., *Halymenia durvillea, Hormophysa triquetra, Hydroclathrus, clathratus, Laurencia* spp., *Padina* spp. and *Sargassum* spp.

The BFAR collaborated with the Seaweed Industry Association of the Philippines (SIAP) by providing partial financial assistance for the toxicological study of Philippines iota and kappa carrageenan which were done in the Philippines and United Kingdom. The UK based BIBRA International completed its toxicological studies in conformity with the high standards of the Joint Experts Committee on Food Additives (JEFCA) guidelines and protocols. The report of BIBRA International did not raise any food safety issues against the Philippines *iota* and *kappa* carrageenan which became favorable to the country.

Formulation studies have been done and continuously being undertaken to come up with a standard procedure for good quality products. Standardization of drying techniques for seaweed has been started with test trials operation of a mechanical hot drier for *Gracilaria* spp. Value added products from *Eucheuma,* such as seaweed candy, noodles (mikie and canton style), cracknel-S, jams and marmalades; and tilapia sausage/frankfurter using agar *(Gracilaria* spp.*)* as extender have been started and in progress.

Produced information materials, i.e. flyer on Phil. Seaweed Resources and its Industry, and hand-outs/brochure on Eucheuma/Kappaphycus culture. The preparation of a National Seaweed Profile based on the Regional Seaweed Profiles submitted by the 14 Seaweed Action Officers has been started and continuously being updated.

Guidelines for market matching have been prepared and disseminated. Promotion of market matching has been undertaken in some areas. The directory of seaweed producers, buyers, processors/exporters has been prepared and continuously being updated.

The Program conducted Trainor's Training on seaweeds R&D to equip BEAR staff involved in the Program. The participants were given lectures and hands-on training on seaweed biology, culture, processing, marketing and management. Trainings and seminars on seaweed culture and processing were held and attended by the various stakeholders of the industry in the different regions.

The Program also actively participated in collaborative projects and activities, such as: ASEAN Industry Carrageean Club, Integrated Seaweed Industry Development and Financing Program, 16th International Seaweed Symposium, First and Second Mindanao Seaweed Congress, National Seaweed Conference 2000 and 2001, and National Technical Committee for Seaweed and Carrageenan. Following is the organizational chart of the National Seaweed Development

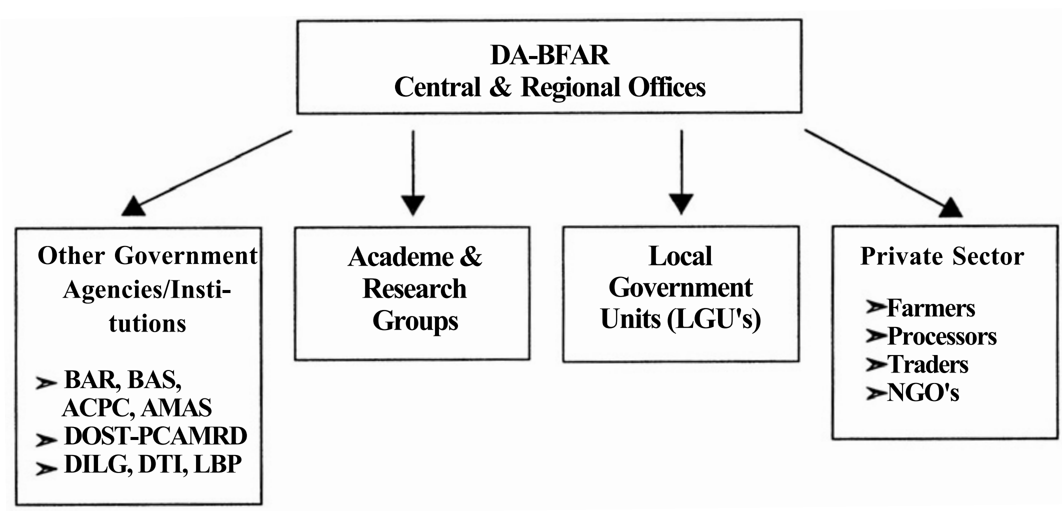

Figure 2. National Seaweed Development

Projects and activities for CY 2001

Research and Development

- Rapid assessment of seaweed resources in selected coastal areas in the Philippines
- Development and improvement of production technologies
- Health management of seaweed
- Provision of post-harvest facilities
- Product development and standardization
- Market matching

Management

- Intensify IEC (production of information materials, dialogue/orientation with the LGU, etc.)
- Drafting of guidelines

Manpower Development

- Upgrading of BFAR Staff
- Training of various stakeholders of the seaweed industry

Institutional Development

- Upgrading of National Seaweed Technology Development Center (NSTDC) facilities
- Establishment of Seaweed Center

Recommendations

Continuation and revitalization of SDP is being recommended in order to address the present issues and problems of the seaweed industry and to meet the gaps on seaweeds R&D. In this regard, the following are recommended:

Resource

- R&D should focus on biological studies and genetics
- Diversify to other potential species with economic value

Production and Health Management

- R&D on the impact of seaweed farming
- Implementation of health management project
- Technical assistance in the formulation of Municipal Fishery Ordinance (MFO) and zonification
- Development of code of practice for seaweed farming
- Expansion of farming areas

Post-Harvest

- R&D on biotechnology, seaweed chemistry and microbiology, and utilization of by-products;
- Provision of post-harvest facilities
- Modern practices on seaweed product development;
- Provision on guidelines/regulation on GMP/SSOP in seaweed processing plant
- Conduct of Hazard Analysis Critical Control Points (HACCP) training
- IEC on village level processing, standards on raw material and carrageenan

Marketing and Cooperative

- Intensify the promotion of market matching
- Assist in the strengthening of SIAP
- Establishment of information data base
- Assist the seaweed farmers on credit availment
- Encourage seaweed farmers to organize themselves into cooperatives for proper access to seminars/trainings in the region.
- Initiate effective trade mechanism to stabilize the price of seaweed

Management

- Strengthen the information and education campaign to create awareness of the public through production of information materials and holding of dialogue/consultation with the local government units and local communities
- Review laws and regulations related to seaweeds farming and management including the zonation of farming areas according to resource use and distribution
- Create Committee to draft FAOs related to seaweed development, utilization and conservation
- Organize community-based management groups to be responsible for the management of the seaweed resources;
- Provide technical assistance in the formulation of municipal fishery ordinance

Manpower and Institutional Development

- Provide equipment and materials needed in the projects
- Develop degree and non-degree programs for BFAR Staff engaged in seaweed projects
- Continue upgrading of the BFAR technical capabilities on seaweeds R&D
- Conduct training for various stakeholders of the seaweed industry

Acknowledgement

For the support and active participation of those involved in the SDP, to wit: DA and BFAR Management, SDP Central and Regional Staff, other government agencies, academic and research institutions and the private sectors: SIAP, seaweed farmers, processors, entrepreneurs, researchers/ students.

Recent Developments in Seaweed Diseases

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Most of what we know about seaweed diseases is generally focused on those affecting the *Eucheuma/Kappaphycus* seaweed, particularly the "ice-ice" disease phenomenon. However, much of our knowledge about seaweed diseases are mainly those observed in non-eucheumatoid algae, especially those cultivated for use as food in Japan, China and Korea namely *Porphyra, Gracilaria,* and *Laminaria.* These diseases vary in terms of their causative agents and manifestations. Table 1 shows the different species of cultivated seaweeds around the world that are known to be affected by microbial pathogens after being pre-disposed by certain factors.

Table 1. Diseases in commercial seaweeds caused by bacteria and other microorganisms

Host seaweed	Name of disease	Suspected causative agent	Environmental condition prior to outbreak	Author*
Porphyra tenera	white rot disease	*Beneckia (=Vibrio)*	exposure to low temperature at extended low tide period	Tsukidate 1983
Porphyra sp.	"suminori" disease	*Flavobacterium* sp.	high temperature	Kusuda et al. 1992
P. yezoensis	"anaaki" or "pin-hole disease"	*Flavobacterium* sp.	low summer temperature	Sunairi et al. 1995
Laminaria sp.	malformation disease	unidentified bacteria	high H_2S content	Uchida & Nakayama 1993
Gracilaria sp.	"rotten thallus syndrome"	*Vibrio* sp.	reduced flow rate in culture tank	Lavilla-Pitogo 1992
	"white rot"	amoeba-like organism		Correa & Flores 1995
G. conferta	"white tips disease"	unidentified bacterium	exposure to high temperature and high light intensity	Weinberger et al. 1994
G. chilensis	lesion/bleaching	agarolytic bacterial strain		Craigie 1995
Chondrus crispus	"green rot" or "green spot disease"	deep orange colored bacteria	surface wounds by mechanical or biological activities	Craigie & Correa 1996
Kappaphycus/ Eucheuma	"ice-ice"	Vibrio sp. P11, *Cytophaga* sp. P25	low salinity, low light intensity	Largo et al. 1995a, 1995b

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Andrews (1976) defined seaweed disease as "a continuing disturbance to the plant's normal structure and function such that it is altered in growth rate, appearance, or economic importance". Is this definition good enough to include the "ice-ice" disease in *Eucheuma/Kappaphycus?* "Ice-ice", as some of us are familiar with, affects not only growth but also its appearance and, possibly, carrageenan product quality. Perhaps, your definition of "ice-ice" disease is as good as this definition by Andrews.

There are two kinds of diseases in plants: infectious and non-infectious type. The former involves a transmissible infectious agent (bacteria, fungi, virus, etc.) while the latter is induced by physiogenic factors such as extremes of temperature, salinity, light intensity or pollution. Other than those in economic seaweeds, most of what is known to be diseases in macroalgae are the types that are generally less threatening to the natural seaweed population. In 1992, however, a form of an algal disease, known as coralline lethal orange disease (or CLOD), caused by an unidentified motile bacterium, consumed a large population of reef-building coralline algae in the South Pacific (Littler and Littler 1994, 1995). This phenomenon underscores the potential of a bacterial pathogen not only to the coral reef ecology but also to the cultivated seaweed species.

Local seaweed species face the similar threat of an infectious type of a disease considering the traditional method of propagating *Eucheuma/Kappaphycus,* since seaweed cultivation started in the Philippines in the late 1960's. The genetic implication of clonal propagation in these seaweeds lies in the tendency of some species to become susceptible to a potential pathogen (Santelices 1992). An "early warning device" in seaweed farming against potential pathogens, such as bacteria, is therefore crucial in the management of seaweed farms. Any approach to this problem would lie on the understanding of the whole seaweed pathosystem in the context of host-pathogen interaction.

There are two important disorders seen in *Eucheuma/Kappaphycus* cultivation that have especially caused problems in recent year. These are:

"Ice-ice" disease. "Ice-ice" is generally caused by unfavorable environmental conditions in the planting site. This is a rather general statement because "unfavorable factors" in the cultivation site refers either to high or low temperature, high or low salinity, high or low light intensity, and also to insufficient nutrient, and so forth. Addressing any of these factors is considered a management intervention strategy. So far, the role of temperature, salinity and light intensity, taken singly was observed in controlled laboratory set up as possible predisposing factors that can lead to "ice-ice" disease. The role of microbial pathogens has also been shown as having to do with "ice-ice". In my own study of the role of bacteria as a lead factor in "ice-ice" disease development, it was discovered that normal (resident) bacteria could become opportunistic pathogens under certain conditions. Subliminal environmental factors (e.g. low salinity, or low light intensity) although in itself may not readily lead to the disease manifestation could predispose the seaweed to bacterial attack, mainly by certain opportunistic pathogens. The seaweed-bacterial pathogen interaction could be akin to those in terrestrial plants. Could it be possible that a highly virulent pathogen is responsible for the wholesale destruction of cultivated seaweed crops in the Philippines? Normally, the surfaces of submerged plants are areas readily colonized by bacteria but only a few strains could be potential pathogens. In the case of *Eucheuma,* two such bacterial pathogens belonging to the *Vibrio-Aeromonas* complex and the *Cytophaga-Flavobacterium* complex demonstrate the seaweed-bacteria interaction (Largo et al. 1995b). Strains of these two groups of bacteria can induce the ice-ice disease in *Eucheuma* when the seaweed plant is subjected to stressful factor of either low

salinity or low light intensity in suboptimal level. While *Cytophaga* sp. P25 showed non-motile behavior, cells of *Vibrio* sp. P11 are active swimmers. This motile behavior of *Vibrio* makes such bacterium an efficient seaweed surface invader. We theorized that it produces hydrolytic enzyme against carrageenan - the compound that makes up the bulk of the cells' interstitial matrices. Indeed *Vibrio* sp. P11 when cultured in a medium of carrageenan instead of agar grows quite well. This ability to digest carrageenan enables the bacterium to penetrate the inner region of the seaweed thallus. I believe that by its lytic activity, it starts digesting epidermal cells, destroying plastids bearing the pigments, hence, the initial bleaching manifestation of the infected part. This leads to gradual hydrolyses of the thallus starting from the cortical layer and into the medulla leading to necrosis (tissue death). There could be other bacteria with similar ability as *Vibrio* sp. P1l that needs to be isolated.

In recent years, many seaweed farms ceased to exist because of the "ice-ice" problem. This has been happening in Bohol, in Batangas, and even in Iloilo. Was it not that widespread "ice-ice" events, if you remember well, took place during the *El Niño* and *La Niña* seasons? What is the probability of "ice-ice" not being caused by microbial pathogens?.

Epiphyte infestation. Epiphytes refer to organisms, small or large, that colonize the surfaces of seaweeds. A serious case of epiphytism has been reported very recently in Calaguas Is., Camarines Norte, and in many parts of the Bicol region. Is this another threat to seaweed farming? Figure 1 shows a common red algal epiphyte, *Polysiphonia* (with dark arrows) and diatoms (broken-line arrow) on *Kappaphycus* thalli. The *Polysiphonia* epiphytes create small, slightly elevated pores on the surface. These pores give "goosebumps" appearance on the thalli surface.

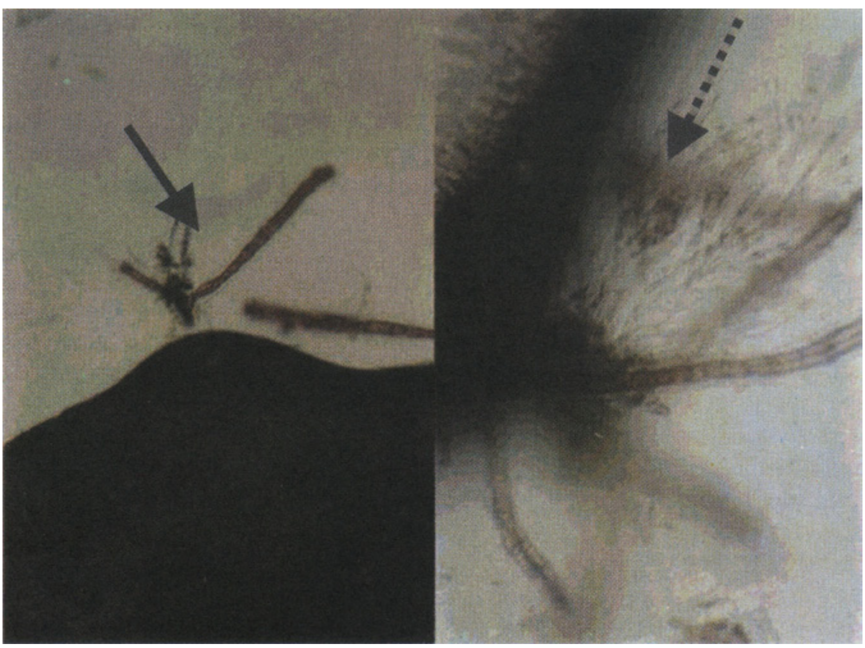

Figure 1. A red algal epiphytes (left away) *Polysiphonia* and diatoms (right away) on *Kappaphycus* thalli.

Microscopic examination of a sectioned thallus (Figure 2) shows that these pores are actually sites of penetration of the epiphytes (with arrows). Whether or not this filamentous alga takes on a more elaborate habit as an endophytic plant will be a subject for future investigation.

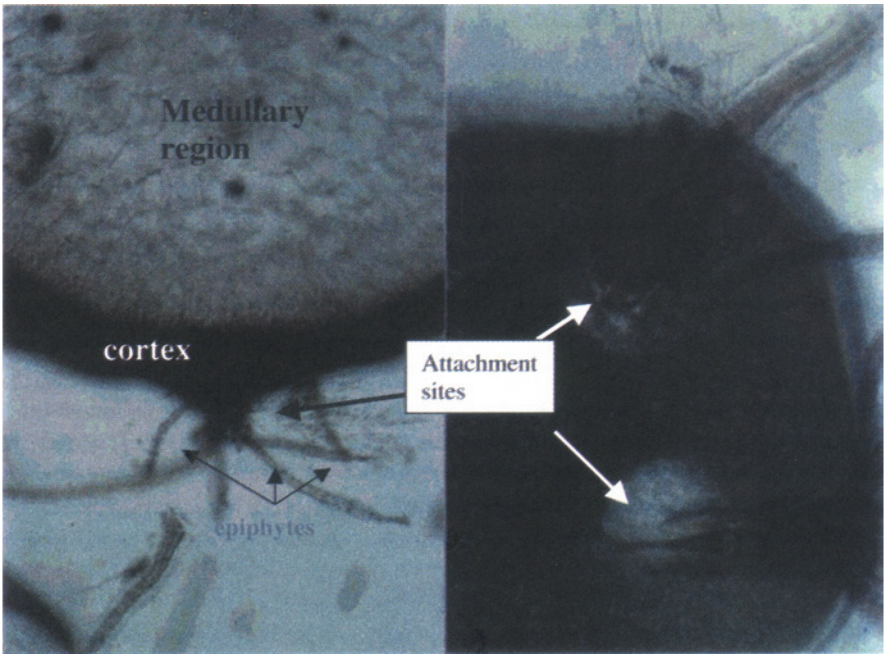

Figure 2. Microscopic examination of sectioned thallus showing actual sites of penetration of the epiphytes, (shown with arrows)

Primary considerations in the diagnosis of disease in seaweeds

Andrews and Goff (1984) recommend that diagnosis, in order to determine symptomatology of a seaweed disease, should not be attempted without familiarity with the algal host affected, preferably by personal experience or, as a minimum, by the study of publications on the growth of the plant and the biotic factors affecting its development. The following needs to be considered:

- the direct or indirect role of environmental factors in disease development;

  that cases in which a primary pathogen is involved such that the disease can be relatively easily diagnosed by symptom (expressions of the host) or signs (visible evidence of the pathogen) will likely be rare;

- that several different diseases may occur concurrently; and

- that visual diagnosis is limited because similar symptoms may result from different agents and, conversely, the same agent (particularly if abiotic) may induce different symptoms in different algae.

It is also important that the suspected organism first satisfies the Koch's postulate to determine whether or not the organism is really a pathogen or not. The following steps are needed to address the Koch's postulate:

- The causal agent must be associated in every case with the disease under natural conditions and, conversely, the disease must not appear in the absence of the agent

- The causal agent must be isolated in pure culture and characterized

- Typical symptoms must develop when the host is inoculated with the agent under suitable conditions, and the appropriate control inoculations be concurrently made

- The causal agent must be re-isolated and demonstrated to be identical to the agent isolated originally

In the case of "ice-ice", the disease may not be necessarily caused by a specific bacterial pathogen. In fact several bacteria, as was shown for *Vibrio* sp. PH and *Cytophaga* sp. P25 can play a trigger role.

Detection of pathogenic organisms

The detection system of a pathogen still relies on the culturability of the organism in an agar medium. Unfortunately, this does not assure the unequivocal proof of association of the suspected pathogen with the host. Biomolecular probe as used in the medical field in detecting disease organisms is yet to be established in seaweed pathology. The potential use of immunology-based techniques has been attempted in seaweeds to detect and monitor the pathogen in the host plant. Direct detection of bacteria, i.e. without agar culture, for instance, has been used to monitor the *Vibrio* sp. P11 in *Kappaphycus alvarezii* (Largo et al. 1998) and in *Gracilaria* species. The method of detection, which utilizes polyclonal antibodies (rendered visible with the use of fluorescent dye such as FITC), was found to be quite effective in establishing the growth behavior of the organism in the thallus. This technique could be made as a practical tool to monitor suspected pathogens. However, it is necessary that the antibodies developed against the target organism should be highly specific and does cross-react with other organisms, either closely or distantly related.

"Ice-ice" disease triggered by bacteria could take place under the following conditions:

- *If there is slow water movement in the cultivation ground.* Some pathogens, especially bacteria, are highly motile and can very easily invade seaweed surfaces. Strong water current, aside from enhancing nutrient exchange, also prevents potential pathogen that comes from the surrounding water from establishing on the seaweed surface (Largo et al. 1997).

- *If the cultivation ground is close to freshwater sources, such as rivers or creeks.* This practically reduces the salinity of the seawater below normal and a stressful factor to the seaweed (Largo et al. 1995a). These places are not the desirable sites for *Eucheuma* farming since it has a normal water salinity requirement of between 33-35 ppt.

- *If water temperature is high, especially if this is accompanied by high light intensity.* This is also stressful to the seaweed. This can be remedied by moving the plants to a slightly deeper location, but not too deep to dampen growth performance. Normal temperature requirement for *Eucheuma* is between 25-31°C.

Although each of the above factors could act independently from each other, they could act synergistically, intensifying the development of "ice-ice" (Largo et al. 1995a). •

Possible management intervention

Crop management will tell us that to optimize production, any crop has to be grown at the plant's optimal growth requirement, with optional external investments on energy. Any factor that tends to deviate from this simple rule will produce bad crop that is below sustainable level.

Some suggestions to properly manage the *Eucheuma* crop:

- Avoid overcrowding plants in cultivation. This renders them susceptible to opportunistic pathogens, like some *Vibrios* and *Cytophagas.* Less crowding of plants also enhances light penetration and therefore to growth.

- Stay within the optimal growth requirements of *Eucheuma.* Drastic changes in salinity and water temperature have to be avoided.

- In times of very high light intensity, as during summer period, especially during *El Niño* seasons it may be advisable to move plants to a deeper location where light intensity does not lead to photoinhibition. Ways to improve planting techniques in such a way that *Eucheuma* crop can be easily moved need to be studied. *El Niño* season is destructive to seaweed cultivation, hence measures to prevent "ice-ice" need to be in place.

- There is a need to identify more "ice-ice" disease-resistant strains of *Eucheuma.* The "sakol" variety of *Kappaphycus alvarezii* seems to have this property. New *Eucheuma* strains from protoplast fusion out of disease-resistant variety are expected to have this desirable characteristic.

Future direction in the study of seaweed diseases

It is clear that seaweed diseases could have a possible effect on seaweed cultivation in the Philippines. Based on our current knowledge of seaweed pathosystem, it is realized that much remains to be pursued in addressing the problems associated with seaweed farming. The following are suggested:

- Research on seaweed diseases and other disorders should be intensified in order to address specific problems related to health management

- The reported phenomenon of intense epiphyte infestation in *Eucheuma* farming (e.g. in Calaguas Island, Camarines Norte) is an emerging problem that needs closer monitoring

- More screenings of potential pathogens based on Koch's postulate should be conducted
- Innovative techniques in the detection of potential pathogens of "ice-ice" should enhance the capability of farmers to monitor possible outbreaks of diseases
- Management strategies in seaweed farming should anchor on sound scientific bases

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Growth with Equity in Mindanao (GEM) Program and the Seaweed Industry

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The Growth with Equity in Mindanao (GEM) Program is a joint undertaking of the United States Agency for International Development (US AID) and the Office of the President that started in 1995 and will end by September 2002. It intends to achieve economic growth in Mindanao and help assure that the benefits of economic growth are widely distributed among the people of Mindanao by focusing on enterprise development, essential infrastructure, and needed policy changes. It works with multisectoral groups to bring about equitable economic growth and actively participates in the integration of marginalized religious and indigenous groups and women into the mainstream of economic development.

One of the sectors being assisted by the GEM Program where Mindanao is noted for is in fisheries and aquaculture. Western Mindanao and the Sulu Archipelago, in particular, are noted for their rich and diverse marine resources and for the past thirty years have been the major source of the *Eucheuma/Kappaphycus* seaweed supplying 70% of the Philippines seaweed production. As part of achieving peace and development in the area in support of the September 1996 peace agreement, the GEM Program launched its Emergency Livelihood Assistance Program (ELAP) in 1997 that provided input assistance to 4,335 combatants of the Moro National Liberation Front (MNLF) to engage in seaweed production in 76 barangays in 26 municipalities in Tawi-Tawi, Sulu, Basilan, Zamboanga City and the Zamboanga provinces. Total assistance extended amounted to more than PhP 80M. A sequel program is currently being finalized that will continue to provide assistance to seaweed farmers.

One of GEM's continuing thrusts is to provide assistance to business support organizations or BSOs. GEM is instrumental in the holding of the 1st Mindanao Seaweed Congress held in April 2000 in Zamboanga City which was attended by the seaweed industry players who realized the need to maintain and strengthen the Philippines' competitive edge against the growing international competition from neighboring Southeast Asian countries. The congress led to the organization of a BSO called the Western Mindanao Seaweed Industry Development Foundation Inc. (WMSIDFI) composed of stakeholders in the seaweed industry in Western Mindanao, Sulu and Tawi-Tawi. During the congress, a position paper indicating the strategies that would address the concerns of the seaweed industry was submitted to the Department of Agriculture (DA) for appropriate action. These strategies cover, among others, research and development (R&D) matters that have to be addressed to improve productivity of seaweed production areas and in expanding new product application of carrageenan.

GEM which has supported the WMSIDFI had again co-sponsored the holding of the 2nd Mindanao Seaweed Congress which was held on April 25-26, 2001 in Zamboanga City. In the congress, a rundown of actions taken with regard to the position paper of the 1st Congress was done and a new set of resolutions was forwarded to the DA to oversee and monitor compliance to the resolutions. One of the resolutions is to support an applied research and development program for the seaweed industry involving DA, the Bureau of Fisheries and Aquatic Resources (BFAR), the Aquaculture Department of the Southeast Asian Fisheries Development Centre (SEAFDEC), the Philippine Council for Aquatic and Marine Research and Development (PCAMRD), UP Marine Science Institute (UP-MSI) and the Department of Science and Technology (DOST). Again, concerns on improving productivity, disease-control, and new product applications as well as product quality control and management to conform with international standards have surfaced.

On-going research activities in Zamboanga City which is being conducted by UP-MSI is being assisted by the GEM Program in coordination with some of the ELAP beneficiaries. In addition, GEM with WMSIDFI are closely coordinating with various government, private institutions, and multi-donor agencies in tapping available human and financial resources that will help improve production and income to members of seaweed growers associations belonging to WMSIDFI and in enhancing their organizational capabilities.

GEM is also funding the update of the *Eucheuma*/Carrageenan Industry Situationer that was prepared by the University of Asia and the Pacific in 1997. This study is considered to be the most comprehensive industry study done so far and the update has included discussions on the other hydrocolloids or gums that are competing with carrageenan. The study is expected to be completed in November 2001.

It is mostly by providing coordinative and advocacy assistance and enhancing the institutional capabilities of WMSIDFI and its members that the GEM Program has assisted the Seaweed Industry.

Seaweed R&D Program of UP-MSI

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Seaweed researches were the earliest activities of the Marine Sciences Center since it started operations in 1975. Farming techniques for *Eucheuma, Caulerpa* and *Gracilaria* were being developed by the Marine Botany Group. Microbiological aspects of the "ice-ice" disease of *Eucheuma* was reported by MSC researchers during the 3rd International Seaweed Symposium while the enzyme carrageenase from sea urchins that grazed on farmed *Eucheuma* was reported earlier. The Center held the first Philippine patent on the refined carrageenan extraction process. Because of its efforts and accomplishments in seaweed and invertebrate research, the Philippine Council for Agriculture Resources Research and Development (PCARRD) honored the Center with Tanglaw Recognition Award in 1982.

Upon the transformation of the Center to Marine Science Institute in 1985, more researches on seaweeds as well as other aspects of marine sciences were conducted earning the recognition as: National Center of Excellence in the Marine Sciences by PD 518 (1994), National Center of Excellence for Marine Sciences by CHED (1998-2001)

Goals

The Institute has three main goals corresponding to research, teaching and technology generation functions. An appreciation of the background goals and research philosophy of the Institute allows better understanding of the Seaweed R&D program of the Marine Plants Academic Group:

- to generate information necessary for optimal and sustained utilization, management, and conservation of the marine environment and its resources;
- to provide graduate level training and extension services to develop manpower requirements in the marine sciences; and
- to develop appropriate and environmentally sound marine-based technologies for industrial and economic development.

Seaweed research, extension and teaching thrust

The March 2001 Research Workshop of the Institute defined the medium and long term research thrust of MSI. These are: Marine Ecosystem Research; Restoration Ecology; Biology and Mariculture of Seaweeds and Invertebrates; Marine Bioindustries (e.g. Biotechnology); Oceanography; Marine Biodiversity; and Applied Marine Research and their associated facilities.

In harmony with the general research thrust, the Seaweed Research Extension and Teaching Thrusts were formulated to include six major areas: Taxonomy and Biodiversity; Biology, Physiology and Culture; Environmental Concerns; Chemistry, Natural Products Utilization: Process and Product Engineering; Molecular Genetics; and Algal Biotechnology. Furthermore, formal and informal training on different aspects of Applied Phycology are envisioned to be offered to fill-in the gap of technical manpower and information in the seaweed industry.

Approaches and issues

As agreed upon, major project and programs incorporated the implementation of the approach and issues raised during the workshop such as the multiplier effect, integrative, multidisciplinary, collaborative, wholistic, pioneering, strategic, group effort, innovative, responsive to needs of science and society, and work and professional ethics and courtesy.

Consequently, the approaches and issues mentioned above are reflected in the current projects funded by Department of Agriculture - Bureau of Agricultural Research (DA-BAR). Examples of these projects are: 1) Development of mitigating strategies for seaweed diseases to sustain/enhance production in farms; 2) Development of quality criteria for cultured carrageenophytes based on harvest time; 3) Development of culture and postharvest technology for small-size and /or mucilaginous seaweed species with high value natural products; 4) Assessment of coastal polyculture system to reduce environmental impact and increase production; and 5) Marine biodiversity of East Asia.

It is interesting to note that while in collaborative research, fairness and equality among collaborators are goals to be achieved, while nurturing aspects also are infused to the collaboration with research- challenged research institutions.

Facilities

It is worth mentioning that MSI maintains the G. T. Velasquez Phycological Herbarium that houses a collection of seaweeds and seagrasses from all over the country. The collection consists of 53,000 mounted specimens belonging to 500 genera and 1100 species of marine plants. The availability to access and retrieve the herbarium data are facilitated with an efficient computerized system.

Worth mentioning too is the Seaweed and Invertebrate Information Center (SICEN). With funds from IDRC, the SICEN project endeavored to collect literature on seaweeds and invertebrate researches here and abroad for easier access by interested parties to pertinent articles and information. At present, the SICEN collection is now a part of the MSI Library.

Recently, with funding from UNDP and DOST-PCAMRD, a seaweed gene bank was established and maintained. The gene bank contains 3 *Gracilaria* species for agar production and 15 strains of *Kappaphycus* and *Eucheuma* that are being fanned for carrageenan production. The seaweed branchlet culture is a source of material for micro-propagation and genetic improvement via biotechnology protocols such as protoplast fusion and gene insertion.

The Institute also has the Seaweed Chemistry Laboratories and Pilot Plant building located some 500 m away from the main building. The seaweed chemistry facility is dedicated to applied seaweed chemistry research. Initial funds to establish the laboratory and pilot plant were provided for by the Ministry of Natural Resources.

Linkages

Similar to the Marine Science Institute, the Marine Plants Academic Group maintains also linkages with local, national and international organizations. Group members represent the institute in a number of national and international committees and organizations concerned with macrobenthic marine plants and marine coastal resources. Some of the members are currently part of editorial boards of local and international journals. Incidentally, the group has produced collectively over 200 publications as journal articles, proceedings and extension materials.

Marine Plants Academic Group

The members of the Marine Plants Academic Group are composed of three professors, one research associate professor, one research assistant professor and one professor emeritus:

Rhodora V. Azanza, Ph.D. Botany
Professor
Algal Physiology, Morphology, Seaweed Culture

Edna Ganzon-Fortes, Ph.D. Marine Sciences
Research Associate Professor
Seaweed Taxonomy, Seaweed Culture, Eco-physiology

Miguel D. Fortes, Ph.D. Botany
Professor
Marine Plant Ecology, Restoration Ecology, Resource Inventory

Arturo O. Lluisma*, Ph.D. Biology
Research Assistant Professor
Molecular Genetics, Algal Culture

Marco Nemesio E. Montaño*, Ph.D. Biological Chemistry
Professor
Marine Natural Products, Algal Polysaccharides, Marine Pollution Chemistry

Gavino C. Trono, Jr, Ph.D. Botany
Professor Emeritus
Seaweed Taxonomy, Ecology, Mariculture

** also belongs to Marine Biotechnology Academic Group*

Assisting the members of the group are highly qualified research assistants who are mostly students of the institute and are on apprenticeship in the field of marine plants.

Conclusion

The marine plants academic group of the Marine Science Institute is capable of responding to the research needs of the seaweed industry. It is ready to collaborate with academic and research institutions in facing the challenges in marine plants research both in the national and international scene.

Seaweed R&D Program of MMSU School of Fisheries

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Topographically, Ilocos Norte is rugged and rocky with majority of the lands used for agriculture with a total land area of 339,934 ha. It has coastal towns where seaweeds abound both in the intertidal and subtidal zones. Seaweed gathering of natural stocks has been an alternative source of income among coastal populace. Some of the seaweeds are gathered for food but the bulk are washed away to the shoreline during stormy days.

The earliest report on marine algae found in Ilocos Norte was made by Gilbert(1943). However, agarophytes were not included despite their significance in the diet as claimed by the Ilocanos. Sulit et al. (1952) attempted to extract agar from *Gracilaria* and *Hypnea,* and carrageenan from *Eucheuma* as well as alginic acid from *Sargassum* and *Turbinaria* species of the Ilocos Region. The same paper mentioned five seaweed species eaten directly including *Porphyra.*

In 1953, Montilla and Blanco prepared a list of 25 species of common seaweeds, including 7 green, 2 brown algae and 6 red algae. Galutira and Velasquez (1963) identified 19 species of edible seaweeds in Ilocos Norte with notes on their food preparations. Cordero's (1976) report on the red algae of the Philippines included several species of red algae in the Ilocos Region such as *Porphyra, Gelidiella,* etc. In 1983, Agngarayngay reported 15 species of agarophytes in Ilocos Norte, Hurtado-Ponce (1983) listed 35 species of edible seaweeds of Currimao, Ilocos Norte in which 14 are agarophytes, and Tungpalan (1987) described 8 agarophyte species. Trono and Ganzon-Fortes (1985) reported 17 species of agar-bearing seaweeds.

An inventory/assessment and utilization of agarophytes of Ilocos Norte was done by Ragasa et al. (1995) which reported seasonal variations on the biomass, agar content and quality of agar produced from five (5) dominant agar-bearing species of red algae. Seasonal variations on the biomass of *Sargassum* species in Currimao, Ilocos Norte was done by Hurtado and Ragasa (1999). Other studies were conducted by students and researchers of the Mariano Marcos State University in collaboration with cooperating agencies like the Philippine Council for Aquatic and Marine Research and Development, UP Marine Science Institute, DA-BAR and DOST-ITDI. Screening of novel sources of carrageenan from other species of red algae is being done. The results of these researches now serve as the baseline for the development and maximum utilization of the seaweed and are now being utilized by researchers, technologists and businessmen.

On Going Projects

- Characterization of carrageenan from selected Philippine red algae and its interaction with food systems, MMSU-DA-BAR Project.
- Assessment of *Porphyra* industry of Ilocos Norte, MMSU Project.
- Culture of economically important seaweeds, Province of Ilocos Norte & MMSU.

Future Projects Awaiting Collaboration

- Improvement of drying method of *Porphyra* with emphasis on mineral content degradation.
- Tissue culture studies on *Porphyra, Eucheuma gelatinae, E. arnoldii* and *Halymenia* species.
- Nutritional evaluation of *Porphyra* and other edible seaweed species.

R & D Strengths

- Diversified seaweed growth both in the intertidal and subtidal zones.
- Presence of staff/players doing R&D activities.
- R&D needs
- Globally competitive cost structures on post harvest marketing and distribution system.
- Collaborators to complement the present structure and technical expertise.

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Seaweed R&D Program of Zamboanga State College of Marine Sciences and Technology

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The Zamboanga State College of Marine Sciences and Technology (ZSCMST) is at present a Zonal Center for aquatic and marine research in Southern Mindanao as identified by the Philippine Aquatic and Marine Research and Development (PCAMRD). The College was identified through the Agriculture and Fisheries Modernization Act (AFMA) of 1997 as a member of the network of selected National Centers for Marine/Capture Research, aimed at modernizing the agriculture and fisheries sector in preparation for the challenges of globalization. As an academic institution, one of the priority thrusts of the college R&D is the development, utilization and management of the seaweed resource in Region 9. The Zamboanga area is one of the seaweed/*Kappaphycus* producers in the country where the region contributes an estimated annual production of 138,265 t of dried seaweeds. Export of dried seaweeds alone generated US$ 6,225,065 for the year 2000 which helped and contributed to the Philippine economy in terms of dollar earning revenue. In terms of ecological importance, seaweeds are considered as primary producers in the marine environment and it also serves as habitat and breeding ground for many marine organisms.

In support of the National Government's vision, through the Department of Agriculture-Bureau of Fisheries and Aquatic Resources-Seaweed Development Plan (DA-BFAR-SDP), the ZSCMST Research and Extension Office formulated and implemented a seaweed R&D projects/activities to meet the needs of the Philippine seaweed growers and farmers in Region 9.

Thus, the College R&D programs and projects for seaweeds are:

Programs/Projects

- Assessment of seaweed/algae stocks in Southern Mindanao
- Establishment of seedling banks from the wild stocks to obtain/produce quality seedlings
- Establish demo-farms in semi-enclosed seas and ponds including genetic studies on seaweeds

Implementing Agencies: BFAR-9, ZSCMST, MSU-Tawi-Tawi, DOST, LGU's

Objectives/Strategies

- To evaluate potential seaweed species for phycocolloid production and to formulate industrial and consumer products from seaweeds

- To develop and improve culture techniques of commercially important species
- To increase production of farmed *Eucheuma*/*Kappaphycus*
- To identify and develop new strains
- To develop value added products

ZSCMST- What We Have Done

(Completed research projects/activities)

- Inventory of macrobenthic algae in the Santa Cruz Islands and West Coast of Zamboanga City
- Ethnobotany of *Solieria robusta* in Zamboanga City
- Initial establishment of Marine Herbarium
- Seasonality and abundance of agarophytes *(Gracilaria* spp.) in Zamboanga and Basilan waters
- Assessment of agar quality from agarophytes *(Gracilaria* spp.) taken from Basilan and Zamboanga waters

ZSCMST (ZONAL CENTER V) R&D plans for CY 2001

- Establishment of *Kappaphycus* seedling bank/nursery at Small Santa Cruz Island
- Inventory of non-geniculate coralline algae in Zamboanga waters
- Assessment of seaweed stocks in Vitali, Zamboanga City and Siocon, Zamboanga del Norte
- Monitoring of growth and survival of *Kappaphycus* strain from Tictabon seedling bank in the West Coast of Zamboanga City

ITDI R&D Activities on Seaweeds

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By virtue of Executive Order No. 128 dated 30 January 1987, the National Science and Technology Authority (NSTA) was reorganized into the Department of Science and Technology (DOST). Under this reorganization, the Materials Science Research Institute (MSRI) was merged with the National Institute of Science and Technology (NIST) and was renamed Industrial Technology Development Institute (ITDI). The ITDI remained to be one of the Research and Development Institutes (RDIs) of the DOST.

ITDI is mandated to conduct research and development (R&D) of technologies using indigenous raw materials of the country for adaptation and possible commercialization in the areas of chemicals and minerals, food processing, electronics and process control, fuels and energy, environmental, material science, and microbiology and genetics. Alongside the development of technologies, ITDI is also mandated to render a wide range of technical services for various sectors of the local industry.

Accomplishments

One of the research areas that ITDI is undertaking is the utilization of seaweeds and its derivative for various industrial applications. A total of 22 research projects (List 1) were completed ranging from process modifications, purification techniques and pharmaceutical applications of marine hydrocolloids. Among the completed projects, the production of hard and soft capsules from carrageenan is the most significant (Fig. 1). It garnered awards and recognition in 1998. The project won 3rd prize in the 8th Scientific Poster Exhibit of Health and Related Technologies, Professional Category sponsored by Philippine Council for Health and Related Technologies (PCHRT) given on July 15, 1998. It also bagged the 1st prize award for the Most Outstanding Creative Research (LIKHA Award) in the National Inventors' Week, given on November 23, 1998. At present, the project is being undertaken in collaboration with Shemberg Marketing Corporation and Drugmakers Laboratories, Inc. for the commercialization studies.

Figure 1. Carrageenan capsules

The on-going projects for this year is focused in the utilization of carrageenan for pharmaceutical products (List 2). The development of absorbable sutures from carrageenan (Fig. 2) obtained the 1^{st} prize award for the 12^{th} Scientific Poster Exhibit of Health and Related Technologies, Professional Category sponsored by PCHRT given on July 20, 2001.

Figure 2. Carrageenan absorbable sutures

For the next three years, ITDI has lined-up several projects for the utilization of carrageenan (List 3). Aside from the regular research projects that are being undertaken, ITDI rendered technical services like contract researches and technology transfer like lecture-demo/training on seaweed processing to would be entrepreneurs. These include the production of gulaman bars, agar, semi-refined and refined carrageenan. List 4 shows the completed contract projects from 1988- 2000 including technical assistance extended to small medium enterprises.

Aside from the local funding that ITDI received from the Philippine Government, other foreign resources are being tapped. A number of proposed projects (List 5) were submitted to various institutions abroad for funding.

ITDI's vision is to be a "world-class S&T Institute with a social conscience, generating and transferring effective and efficient technologies, and providing quality and reliable services to industry and country, for the upliftment of the quality of life of the Filipino people".

List 1. Completed projects, 1984-2000

1. Agar-agar production and purification process
2. Local production of agar-agar from *Gracilaria verrucosa* (Hudson) Papenfuss for microbiological, food and pharmaceutical applications
3. Pharmaceutical uses of NIST-purified agar
4. Alginic acid from *Sargassum* species
5. A modified method of producing alginic acid from *Sargassum*
6. Extraction of an agar-like mucilage from *Digenea simplex*
7. Development / production of USP grade excipients/additives from technical grade materials
8. A formulated stabilizer-emulsifier with dispersible hydrophillic colloid (carrageenan) for pharmaceutical/cosmetic use
9. Local plant hydrocolloids-properties and pharmaceutical uses
10. Agarose from *Gracilaria* species (lab-scale)

11. Post-harvest treatment of seaweeds
12. Seaweed tablet as natural source of iodine
13. Bench-scale production of agarose from *Gracilaria* species
14. Production of *lambda* carrageenan from *Halymenia* species
15. Development of new products from carrageenan: Transparent film and absorbable gauze pad
16. Alternative method for the production of refined carrageenan
17. Dermopharmacy of seaweed extractives
18. Isolation and characterization of hypocholesterolemic substance from seaweeds
19. Pharmaceutical products from carrageenan (anti-coagulant and hypocholesterolemic agent)
20. Scale-up studies on the production of refined carrageenan using the alternative method
21. Production of hard and soft capsules from carrageenan
22. Pre-commercialization studies of carrageenan capsules

List 2. On-going projects, 2001

1. Absorbable sutures from carrageenan
2. Development of packaging materials from carrageenan
3. Commercialization studies of carrageenan capsules with Drugmakers Lab. Inc. and Shemberg Marketing Corporation

List 3. Projects to be implemented for the next three years

1. Utilization of carrageenan for the production of surgical gloves and suppositories
2. Production of fat burner soap using seaweed extracts
3. Carrageenan in drug delivery system
4. Utilization of carrageenan for the production of spermicide film

List 4. Completed contract researches and technical assistance extended

A. Completed contract researches, 1988-2000

1. SGV-ITDI feasibility studies on carrageenan
2. DMMSU-ITDI feasibility studies on semi-refined carrageenan
3. FMC (Marine Colloids Phils. Inc.) - ITDI pre-feasibility studies on the establishment of a food grade agar extraction plant
4. Production of semi-refined carrageenan (Mr. Chua as proponent)
5. Production of semi-refined carrageenan (Mrs. Abengoza as proponent)
6. Feasibility studies on the establishment of a carrageenan plant in Samar
7. Feasibility studies on the establishment of a carrageenan plant in Antique
8. ITDI-Shemberg joint studies on carrageenan capsules

B. Technical assistance extended

1. Pilot production of bacteriological-grade agar in Zamboanga City
2. Production of gulaman bars in Lavizares, Northern Samar
3. Production of gulaman bars in Pulilan, Bulacan

List 5. Proposed projects for foreign funding

1. Purified iodine from seaweed
2. Natural products from seaweed
3. Production of chlorophyll and its derivatives from red and brown seaweeds
4. Development of a mild anesthetic drug from *Caulerpa* species
5. Carrageenan film technology
6. Functional oligossacharides from carrageenan
7. Carrageenan for microencapsulation of various drugs

Seaweed Projects funded by PCAMRD

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This paper reports the different seaweed projects funded by the Philippine Council for Aquatic and Marine Research and Development (PCAMRD). The research areas are focused on inventory and assessment, and processing and utilization of the economically important seaweeds of the Philippines (*Eucheuma, Gelidiella, Gracilaria, Gracilariopsis, Kappaphycus,* and *Sargassum*) see following table.

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
INVENTORY AND ASSESSMENT		
1. Inventory, assessment and utilization of agarophytes and alginophytes in the waters of northern Mindanao - **Wilfredo Uy**, MSU-Naawan	General Objectives • To determine the sustainable yield levels of *Sargassum* spp. & *Gracilaria* spp. in Northern Mindanao • To determine the effect of seasonality & biomass levels on the quality of agar and algin • To provide immediate & preventive measures to sustain production & initiate assessment of these measures	
1.a Assessment of *Sargassum* spp. & *Gracilaria* spp. in the waters of Northern Mindanao- **W. Uy**	Specific Objectives: • To identify species of *Sargassum* & *Gracilaria* found along the coastal waters of Northern Mindanao (including its macroflora and faunal associates) • To determine the seasonality and biomass levels of *Sargassum* & *Gracilaria* spp. in the area • To determine physico-chemical parameters in the area and correlate these with seasonality, species richness, zonation and algin/agar quality	• From the 6 stations established, 116 species of macrobenthic algae were identified. There were 49 red, 30 green, 25 brown and 4 bluegreen algae. *Sargassum* has 8 species while *Gracilaria* has 9 species with an unknown species from Camiguin island. • The project facilitated the approval of a local municipal ordinance prohibiting the harvest of *Sargassum* along the coast of Naawan. This was done after a series of public hearings participated in by researchers, local officials and seaweed collectors

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
1.b Assessment of agar and alginate quality of *Gracilaria* & *Sargassum* spp. in Northern Mindanao area - **Grace Prado**	• To assess the physical quality of agar and alginate from the different *Gracilaria* and *Sargassum* species, respectively • To determine seasonality of agar and alginate quality	• In the stations surveyed, *Sargassum* has the widest bed except in Lala, Lanao del Norte where there was none because of the muddy substratum. *Gracilaria* was found to be abundant in this area. Results showed that *Sargassum* spp. are generally abundant in Maigo station with 40% algal cover during January and April. • For *Gracilaria,* Initao station has the most number of species and it is generally present throughout the year. • The most dominant macrobenthic algae was, *Sargassum crassifolium,* followed by S. *ilicifolium, Gelidiella acerosa* & *G. arcuata.* Other species identified include *Padina* spp., *Turbinaria conoides, Laurencia papillosa, G. coronopifolia, Ulva reticulata* & *Cladophora* sp. • Data gathered indicates that *Sargassum* was generally vegetative. • Samples of agar from *Gracilaria* & alginate from *Sargassum* were analyzed at the UP Marine Science Institute.
1.c Management strategies for the conservation & utilization of agarophytes and alginophytes in Northern Mindanao - **G. Prado**	• To develop community-based management of seaweeds in Northern Mindanao with a focus in *Sargassum* and *Gracilaria*	
2. Utilization of agarophytes in the waters off Ilocos Norte -**A. Ragasa** 2.a Inventory/assessment and utilization of agarophytes in Ilocos Norte	• To determine the seasonal variation of yield and quality of agar from the various species of agarophytes • To evaluate and assess the physico-chemical qualities of the agar • To correlate seasonal variation with agar quality • To develop products and test-purify agar extracts as culture media for microorganisms	There were five dominant agarophytes collected namely *Gracilaria coronopifolia, G. eucheumoides, G. salicornia, Laurencia flexilis* and *Gelidiella acerosa.* The highest agar yield was registered from *G. coronopifolia,* in the month of April. Agar yield could be attributed to the stage of growth and development of the seaweeds. *G. acerosa* had the highest gel strength while *G. coronopifolia* the lowest. Viscosity of agar showed *L. flexilis* to be the highest with *G. coronopifolia* as the lowest. The sulfate content analysis showed *L flexilis* and *G. coronopifolia* to have high values with *G. acerosa* having the least value. *G. salicornia, G. acerosa* and *G. eucheumoides* have high values in 3,6 anhydrogalactose while minimal values was registered by *G. coronopifolia.* High ash content was shown by *L. flexilis* while *G.*

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
		acerosa has the least. The gelling temperature of L *flexilis* was highest and *G. coronopifolia* the lowest. As to the melting temperature, *G. acerosa* had the highest while *G. eucheumoides* the lowest. Significant correlation between yield and physico-chemical properties of extracted agar were observed among the agar extracts. Bio-physico-chemical factors were significantly related to yield. All agar extracts were acceptable but in the product formulation, *Gelidiella acerosa* received the highest acceptable rating. Microbial examination of the agar gave minimal microbial counts. Purified agar extracts from the agarophytes could be used as culture media for selected microorganisms.
3. Inventory, assessment and utilization of agarophytes and alginophytes in the waters of Cebu and Bohol - **F. Sotto**		
4. Inventory, assessment and utilization of agarophytes and alginophytes in the waters of Negros Occidental and Oriental **H. Calumpong**		
5. Assessment, management and utilization of agarophytes and alginophytes in selected coastal areas of Zamboanga and Basilan waters - **P. Domingo, F. Saupi, M. Ontolan and F. Piedad**		
6. Assessment, management and utilization of agarophytes and alginophytes in		

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
selected areas in Cagayan waters - **R. Domingo**		
7. Training Program and Coordination on Taxonomy of *Gracilaria* and Processing of agar - **N. Montaño**		
8. Inventory and assessment of *Gracilaria* and *Sargassum* in selected areas of the Philippines **G. Trono, Jr. -** UPMSI **R. Sariego** - SPCP **J. Manzano** - BUTC **E. Mamaril -** DMMMSU	• To inventory and assess the natural stocks of *Gracilaria* and *Sargassum* in selected areas in the Philippines • To determine the seasonality in standing crop and reproductive phenology of the stocks • To formulate and implement managed harvest schemes for the utilization and conservation of the stocks	Inventory and assessment of *Sargassum* and *Gracilaria* were conducted at selected areas in the country using the method of Saito and Atobe. Sargassum stocks reach their peak growth, standing crop and fertility during the cold months - November to December and die-off the following months of January-February. Regeneration and growth resumed afterwards. Large and well-developed *Gracilaria* stocks appeared to be limited in their distribution in highly fertilized waters in coves, lagoons, near mouth of rivers, and landward portions of reef adjacent to mangrove communities during the summer months of April, May and June and disappeared during the rainy month of July to December.
9. Development of *Gracilaria* cultivars from seaweed farms in open water - **G. Trono, Jr.**	• To select and develop fast growing, high yield and good agar quality *Gracilaria* species/cultivars for the seaweed farms in open waters Specific Objectives: • To compare the growth of the different species in controlled conditions and to use the culture materials for agar extraction and characterization. • To compare the agar quality of the cultured materials to field collected materials of the same species. • Using the results in objectives 1 and 2, to select the species or strain with high agar yield and quality for mass production as cultivars for commercial farming.	Three local agarophyte species (*Gracilaria firma, Gracilaria* sp. and *Gracilariopsis bailinae*) were grown under controlled outdoor flow-through culture conditions. Growth rates and agar characteristics of the three species were determined. *G. firma* showed superior growth and agar quality among the three species. It exhibited the highest growth rate, highest agar gel strength and was observed to be highly resistant to epiphytes. Growth experiments under various light fluence and ammonium combinations showed that the highest light fluence level and moderate ammonium concentration resulted to highest growth rates for all species. The single and interactive effects of light fluence and ammonium enrichment on growth and agar characteristics of the three species were highly significant. Field culture of the three species is feasible though seasonal. *Gracilariopsis bailinae* is suitable for pond culture while *G. firma* and *Gracilaria* sp. are best suited in open water culture.

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
	• To develop hatchery techniques in the mass production of the selected species. • To conduct field culture trials using the hatchery produced cultivars and finally extend this technology to farmer cooperators.	
10. Development of germling production and culture technology of *Sargassum* - **G. Trono, Jr.**	• To develop the technology for the hatchery production and culture of *Sargassum* germlings • To conduct field studies on the rehabilitation of over-exploited/ecologically stressed *Sargassum* beds and development of *Sargassum* bed. Specific Objectives: • To establish the individual and combined effects of photon flux density, culture media and salinity on the growth and survival of *Sargassum crassifolium* germlings under laboratory conditions • To determine the optimum laboratory conditions for the growth and survival of *S. crassifolium* germlings • To compare the growth and survival of *S. crassifolium* juveniles cultured in the laboratory and transferred to hatchery and field conditions • To determine the individual and combined effects of photon flux density, culture media and salinity on the growth and survival of juveniles in the hatchery • To know the recruitment capacity of *Sargassum* germlings on artificial substrates and recommend the	The effects of photon flux density, culture media and salinity on the growth and survival of *Sargassum crassifolium* germlings shed on artificial substrates showed that the main and interactive effects of salinity and photon flux density significantly affected the growth of the germlings during the entire culture period. Growth was enhanced with the addition of media during the later part of development. Survival rate was shown to be influenced mainly by photon flux density with higher rate at 100 than at 200 uEm^{-2} s^{-1}. In the hatchery, where the germlings were transferred for further growth, the most favorable culture condition was filtered seawater with ES enrichment at 35 ppt salinity and 300 uEm^{-2} s^{-1} photon flux density. The interactive effect of salinity and photon flux density appeared to be more deleterious than their individual effect. High mortality rate observed on the germlings deployed in the field was due to grazing. The germlings had to be grown to plantlets further in the hatchery before being deployed in the field. Results of *in situ* recruitment studies on concrete cement blocks showed that more germling were recruited on the blocks deployed during the colder months of October to January coinciding with the fertility peak of *Sargassum* populations in the area. Blocks during low fertility months were overgrown by other algal species preventing the settlement of *Sargassum* germlings. The best time recommended for substrate deployment would be September to December. The recruitment capacity of the *Sargassum* populations appeared to vary with time. Environmental parameters monitored did not seem to have a significant effect on the recruitment rate. Grazing appeared to be an important factor affecting recruitment.

Status of seaweed R&D

Title/Project leader	Objectives	Accomplishments
	period for substrate deployment. • To determine the feasibility of establishing *Sargassum* beds using spore bag technique	
SEAWEED PROCESSING AND UTILIZATION		
1. Development of fertilizers/ growth hormones from Philippine seaweeds - **N. Montaño & A. Corpuz**	• To develop seaweed sources of low-cost fertilizers and/or growth hormones Specific Objectives • To develop fertilizers/growth hormones from seaweeds and seaweed waste through different extraction procedures • To assay for the growth hormonal substances present in these fertilizers • To analyze the micronutrient contents of the seaweed and the seaweed extracts • To conduct pot and field experiments to determine the effectivity of the fertilizers. • To determine the effective concentrations for seaweed fertilizer applications • To conduct laboratory experiments to ascertain the effectivity of seaweed extracts in delaying the ripening of fruits and the wilting of cut flowers.	*Sargassum* extract was tested as fertilizer for chrysanthemum, pechay, strawberries, carrots, potatoes, tomatoes, lettuce and as Postharvest treatment for tomato and chrysanthemum. Results showed that there was no significant effect on the growth performances of the above test crops when it was used as fertilizer. On the other hand, application of the seaweed extract significantly affected the final height of chrysanthemum. Its effect on the number of days from flower bud formation to anthesis and flower diameter was comparable to the effect of the use of commercial with chicken manure fertilizers. The combination of seaweed extract and inorganic fertilizer gave a significant effect on the growth and yield of potato. Hot processed seaweed extract at 0.5% was seen to be most effective when used as a supplemental fertilizer for tomato. Postharvest studies of salad tomato showed that ripening was delayed in fruits treated with 1.0% seaweed extract while increased seaweed extract concentrations of 1.5% and 2.0% hasten ripening of tomato fruits. Holding cut chrysanthemum flowers in 1.0% and 0.5% seaweed extracts resulted in delayed flower deterioration as exhibited by better overall visual quality, better foliage and prolonged vaselife.
2. Search for new sources of carrageenan from Philippine seaweeds and the development of applications for unmodified carrageenan - **N. Montaño**	• To search for new sources of *lambda* carrageenan from Philippine seaweeds • To search for new sources of unmodified carrageenan *(kappa, iota, mu, nu* and *lambda)* from Philippine seaweeds • To determine the physico-chemical properties of *lambda* and unmodified	Three seaweeds, namely *Hypnea* sp., *Bostrychia* sp., and *Eucheuma gelatinae* were identified as potential sources of carrageenan. These sources were identified on the basis of yield, and conformity with the regulations as stated in the Food Chemicals Codex 3rd ed. The results showed percentage yield and infra-red spectroscopy information. On the other seaweeds, data pertaining to the sulfate content were also collected and for those extracted polysaccharides that were able to form a gel, the melting point and gelling point of the gel in the presence of various ions were determined to establish the polyssacharide's ionic

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
		reactivity. Although *Gelidium* sp. and *Gracilariopsis* sp. are identified as agarophytes, the experiments revealed that their polysaccharides react with methylene blue, and contain a high sulfate content from which one might infer that they are carrageenans. However, these data also point to the possibility that the polysaccharides may be similar to fumoran, a sulfated agarose obtained from the seaweed *Gloiopeltis furcata.*
3. Nutritional evaluation of Philippine semi-refined carrageenan - **L. Panlasigui**	• To evaluate the nutritional benefits of carrageenan-incorporated foods. Specific Objectives: • To formulate and evaluate the nutritional composition of food products with carrageenan such as pan de sal, fishball, longganiza, hamburger patty, gelatin and gumdrop (at varying levels of carrageenan) • To investigate the effects of carrageenan incorporation into food products on blood glucose level	Nutritional evaluation showed that carrageenan incorporation increases the dietary fiber content of the tested food items from 1.60% to 58.40%. Pan de sal and fishball with varying amounts of dietary fiber ranging from 10.95 to 32.57 g were given to normal and non-insulin dependent diabetic subjects. Control and experimental food samples were calculated to contain 50 g of total available carbohydrate. Results show that pan de sal formulation 1 did not significantly reduce the post prandial glucose rise in normal and diabetic subjects. It appears that for fiber to have an effect on blood glucose response, more than 12 g dietary fiber has to be present in 50 g available carbohydrate. The fried fishball study results showed that carrageenan incorporation significantly reduced blood glucose levels. Soluble fiber has been shown to increase viscosity of luminal content, and therefore delay the digestion and absorption of some nutrients such as carbohydrates. This accounts for the reduced post-prandial glucose levels. For blood glucose to be reduced significantly, the ingredients should be properly proportioned and manipulated aside from containing more than 12 g dietary fiber per 50 g available carbohydrate portion of the food.
4. Development of new carrageenan products from selected Philippine red seaweeds - **N. Montaño**	• To screen different sources of *mu, nu, lambda* and other carrageenans • To determine the physico-chemical properties of the different carrageenan such as gel strength, viscosity, gelling and melting temperatures, sulfate and 3,6-anhydrogalactose contents and others. • To determine whether these	The different samples of *Eucheuma spinosum* and *Kappaphycus alvarezii* collected from Bolinao, Pangasinan and Cebu were subjected to three different methods of extraction, two of which were modified. The first modification is the alkaline treatment wherein most of the carrageenophytes yielded products with higher viscosity, gel strength, gelling and melting temperatures and 3,6-anhydrogalactose content and lower sulfate content. The other treatment is borohydride, which yielded carrageenans with lower viscosity and gel strength as well as the gelling and melting temperatures. It also lowered the 3,6

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
	carrageenans could be used for food and technical products such as beer, milk and others.	anhydrogalactose content of carrageenan extracted from *E. spinosum*. The carrageenans extracted were used in the formulation of fruit-flavored candy gels and pastilles. An air freshener gel was also formulated using a certain carrageenophyte. These said products have their patents pending.
5. Mass production of mannitol from *Sargassum* seaweeds - **N. Montaño**	• To develop an efficient method of mass extraction and purification of mannitol and to further characterize the extracted mannitol by chromatography, IR and NMR and molecular weight determination.	*Sargassum* collected from the sampling sites were screened for % mannitol content using periodic method. The most successful method of extracting mannitol from the seaweed involves the use of an acid solution with subsequent purification by crystallization or ethyl alcohol.
6. Pigments from Philippine marine sources - **B. Glorioso**	• To develop the technology for extracting pigments from various marine sources specifically the seaweeds.	Organic solvent and water soluble pigments from the following seaweeds have been extracted: *Halymenia durvillaei, Acanthophora spicifera, "Laurencia tronoi", Sargassum* sp. and a genetically improved seaweed from Nova Pacific Research Institute called *Gracilaria* NBr-10. Different procedures were tried in pigment extraction. Hot and cold and polar and non-polar solvents were used to determine the different solubilities of the pigments. Of the seaweeds screened for pigments, the red seaweed, *H. durvillaei* was given more attention since it yielded a bright red water soluble pigment which showed two separate peaks by high performance liquid chromatography (HPLC) The red pigment could be well utilized as food colorant but would find more valuable application as fluorescent tags with numerous applications in flow cytometry, fluorescent activated cell sorting, histochemistry, in immunoassays and also in the detection of relative oxygen species. The brown seaweed *Sargassum* sp. yielded two types of pigments constituting the polar and non-polar fractions. The polar fraction contained light brown to orange water-soluble pigments while the non-polar fraction yielded pigments believed to be composed of fucoxanthins or carotenoids. The carotenoids would be quite valuable as antioxidants, food supplement and as food.
7. Development of Philippine seaweed polysaccharide for food and industrial	• To develop the bench scale technology for preparing phycocolloid derivatives, phycocolloid based/stabilized	Products incorporating algal polysaccharides were developed. Interactions of carrageenan with some food and industrial substances such as glycerol, albumen, gelatin and antibiotics were also

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
application - **N. Montaño**	food and pharmaceutical formulations • To determine the shelf-life of the formulated products	investigated. The products formulated are as follows: Halimuyak Gel Soap, Halimuyak Liquid Soap, Ginhaua Ointment, Suppository Base, Low Calorie Jelly, Egg Coatings, Decorating Gel, Instant Gum Paste and Low Calorie Maple Syrup
8. Screening of high quality agar from Philippine red seaweeds and development of appropriate processing techniques for agar - **N. Montaño**	• To screen different *Gracilaria* species and red seaweeds for good quality agar • To develop appropriate processing techniques for improving agar quality especially its gel strength • To test and classify the agars whether they are food, sugar reactive or micro-biological grade • To characterize and elucidate the structure of the extracted agar • To undertake shelf-life studies on the extracted agars	*Gracilaria* species as well as other equally important agarophytes which were collected from different parts of the country were screened for good quality agar. Native agar was extracted by boiling the algal samples in water for one hour. However, pressure cooking (15 psi at 120°C for an hour) was employed in the extraction of native agar from seaweeds that possess hard thalli. A combination of irradiation at kGy and pressure-cooking is a good extraction procedure for *Gelidiella acerosa* while G. *eucheumoides* exhibited better agar quality when pre-treated with 10% NaOH at 90° C for 2 hours. *G. eucheumoides* needs to be processed immediately after collection if high gel strength is desired, however, it could still be stored for a max of 6 months where Theological properties are still optimum. The seasonal evaluation on the quality of agar showed that *G. acerosa* registered high agar yield and gel strength during the rainy months between July and September while better quality agar was extracted from *G. eucheumoides* in the month of July. *G. edulis* registered maximum yield, and gel strength and other rheological properties during the month of May. Chemical analysis and spectrophotometric data revealed that agar extracted from the different seaweeds is composed mainly of 3-linked b-galactose and 4-linked 3,6-anhydro-a-L-galactose as the dissaccharide repeating unit. However, substituents like methyl ethers, sulfate esters and pyruvate ketals were present at varying degrees which explain the differences in the gelling properties. Alkali-treated agars from *Gracilaria eucheumoides, G. arcuata, G. tenuistipitata, G. edulis, G. salicornia, G. firma, Gelidiella acerosa, Gracilariopsis heteroclada* and *Laurencia flexilis* exhibited a maximum gel strength of 430, 278, 606, 225, 220, 820, 947 and 200 g cm^{-2}, respectively. Of the agarophytes studied, *G. eucheumoides, G. salicornia, G. firma* and *Laurencia flexilis* are potential sources of sucrose-reactive agars since their agar gels were more than two times stronger when added with 50% sucrose which possessed high water holding capacity.

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
9. Interaction of paralytic shellfish poisons (PSP) with algal polysaccharides - N. **Montaño**	• To assess the interaction of algal polysaccharides with the red tide toxins and to develop their use as PSP antidotes Specific Objectives • To determine conditions for toxin-algal polysaccharide interactions, i.e., pH, temperature, concentration, etc. • To compare the interactions of red tide toxin with algal polysaccharides, ion exchange resins, and C18 resins • To conduct *in vivo* and *in vitro* assays of the toxin • To develop other tests for the toxin in conjunction with proposed IAEA project on red tide	The poisons used in the study were both crude extracts. PSP was extracted from *Pyrodinium bahamense* var. *compressum* and puffer fish poison was extracted from puffer fishes. When tested in mice, both crude extracts were toxic and hence were presumed to be positive of the toxins. PSP extracts were confirmed of the presence of saxitoxin (STX) but the puffer fish poison was not confirmed of the presence of tetrodotoxin (TTX) In the assessment of the in vitro interaction of PSP with algal polysaccharide, it was found that the gels of alginates and the carrageenans can reduce toxicity of the poison. The sol form of these polysaccharides does not have toxicity - reducing properties but seem to show toxicity potentiation properties instead. However, the gel form of these polysaccharides has very good poison-sequestering properties. When k-carrageenan was used as a model of polysaccharide gels, the partial characterization showed that the interaction was surface area-dependent, polysaccharide concentration-dependent and interaction-time dependent. It was also shown that the interaction was irreversible in isocratic conditions and was negatively affected by the presence of salts and proteins. The *in vivo* experiments on PSP showed that there was a delay in the onset of symptoms of paralytic shellfish poisoning. The *in vitro* assessment of the interaction of pufferfish poison with the carrageenans showed that the three carrageenan types can sequester the poison especially in the gel form. When k-carrageenan was used as a model, it showed that puffer fish poison-carrageenan gel interaction is concentration and time-dependent. Unlike with PSP, toxicity of puffer fish poison can also be reduced using the sol form of carrageenan.
10. Studies on the properties of an algal polysaccharides and its interaction with other gums: carrageenan - **N. Montaño**	• To search for galactomannans or mannans from Philippine indigenous sources which are synergistic with carrageenan • To determine the physico-chemical properties of mixtures of different carrageenans and native gums	

Status of seaweed R&D

Title/ Project leader	Objectives	Accomplishments
	like ipil- ipil seed gum, galactomannans and mannans, industrial and indigenous gums • To serve as a clearing laboratory for carrageenan that is to be used for chemical derivatization to produce related to material science	
11. Management of natural stocks and the development of farming and processing technologies for *Gracilaria* for the socio-economic upliftment of the coastal communities in Northern Mindanao - **B. Que**	• To develop appropriate farming and processing technologies for *Gracilaria* and disseminate this technology to fisherfolks for the development of alternative employment opportunities and improvement of their socio-economic conditions. Specific Objectives • To develop appropriate farming techniques for *Gracilaria,* including evaluation of agar quality, test farming and determine the viability of culturing *Gracilaria* singly or together with prawns, crabs, shellfish or finfish in ponds, cages and/or in the open sea • To organize fisherfolks for farming by putting up demonstration farms as seedling banks, develop manuals and conduct seminars on farming and processing not only to fisherfolks but also to NGOs, GOs and private parties who can help in the development of the industry. Free consultancies/ technical assistance will also be provided to farmers.	The five coastal areas surveyed include Guinsiliban, Benoni, Mantigue, El Salvador and Balingasag. The different varieties of *Gracilaria* propagated came from Ubay, Bohol; Laguindingan, Misamis Oriental and from Kalawisan, Cebu. A seedling bank in Laguindingan was installed and a farming manual was developed. Three core groups were organized for *Gracilaria* farming and all of them are ready to proceed expansion for their *Gracilaria* farms. Three manuals were published: *Gracilaria* Farming, Agar Processing, and Food Applications of Agar. A product called AC10 was developed. Several food applications with agar as stabilizer were developed - Chocolate Cream Special, Instant Leche Flan, Peanut Gulaman Candy, Fruit Jello, Gulaman Peaches Dessert, Mango Ice Cream, Cream Fruited Squares, Mango Float, Nata Choco Jello, Langka Float, Corn Gulaman Special, Pineapple Gulaman Special, Cream Gulaman Special, Gulaman Float

Seaweed Projects Funded by DA-BAR

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The Bureau of Agricultural Research (BAR), one of the staff bureaus of the Department of Agriculture (DA), is mandated to plan, coordinate, monitor and source out funds for Research and Development (R & D) in agriculture and fisheries. This task has been emphasized with the implementation of the Republic Act 8435 or the Agriculture and Fisheries Modernization Act (AFMA), where BAR is entrusted to enhance, support, consolidate and strengthen the existing National R&D System in Agriculture and Fisheries (NARDSAF).

For over fifteen years, cultivation of seaweed has been identified as a priority commodity in the national R & D agenda and programs. These are the following: National Fisheries Research and Extension Agenda (NAREA) for Agriculture and Fisheries (1987-1989); National Fisheries Research Program (NFRP) in 1990-1994; and the National Fisheries Research & Extension Agenda (NAFREA) in 1995-1998. The latest updating was in 1999 when the National Integrated Research, Development and Extension Agenda and Program (NIRDEAP) for fisheries was formulated for the three subsectors: Capture Fisheries, Aquaculture, and Fisheries Post-harvest & Marketing. The national program embodies the priority R&D thrusts and priorities of the sector.

Very few R&D projects were funded by BAR due to limited budget allocation for grants and lack of proposals submitted and approved for implementation. However, when AFMA was implemented, there was a little increase in BAR's budget for R&D. It was also during this period when the National RDE Networks for Capture Fisheries, Aquaculture, and Fisheries Post-harvest & Marketing were organized. The NIRDEAPs were formulated and based on these, priority R&D projects were reviewed and funded to address the seaweed industry's need for improving farming systems, improvement of strains and development of new strains for culture, and post-harvest concerns. Tables 1 and 2 show the completed and on-going BAR-funded projects on seaweeds.

Table 1. Completed BAR-funded Projects on Seaweed

Title	Institution	Project Leader	Period of Implementation
Polyculture of *Gracilaria heteroclada* and *Penaeus monodon* in brackishwater ponds	SEAFDEC AQD	Anicia Q. Hurtado	December 1992-November 1993
Seasonal variation in agar quality and quantity of *G. heteroclada* cultured in ponds		Ma. Teresa de Castro	
Economic feasibility of the polyculture of seaweed (*Gracilaria* sp.) with tiger prawn (*P. monodon*) in brackishwater ponds		R. Agbayani	
Field Guide & Atlas of the Seaweed Resources of the Philippines	UP Marine Science Institute	Dr. Gavino S. Trono	1995-1997

Table 2. On-going BAR-funded Projects on Seaweed

Title	Institution	Project Leader	Period of Implementation
Evaluation of different culture systems of seaweed farming in the coastal areas of Malalag Bay	Department of Agriculture, RFU IX, Davao City	Mr. Jose A. Villanueva	January 1999- December 2001
Development of mitigating strategies for seaweed diseases to sustain/enhance production in farms	UP Marine Science	Dr. Edna Ganzon-Fortes	January 2000 - December 2003
Development of quality criteria for cultured carrageenophytes based on harvest time	UP Marine Science Institute	Dr. Nemesio E. Montaño	July 2001 - December 2003
Characterization of carrageenan from selected Philippine red algae and its interaction with food systems	Mariano Marcos State University-College of Fisheries	Prof. Anita Linda R. Ragasa	April 2001 - March 2004
Use of spores and sporelings in the development of strains and farming techniques for *Gracilaria*	UP Marine Science Institute	Dr. Rhodora V. Azanza	May 2001 - April 2004
Development of culture and post harvest technologies for small-size and/or mucilaginous seaweed species with high value natural products	UP Marine Science Institute	Dr. Gavino C. Trono	July 2001 - August 2004
Field Guide & Atlas of the seaweed resources of the Philippines. Volume II	UP Marine Science Institute	Dr. Gavino C. Trono	May 2001- April 2002

Seaweed Research at SEAFDEC/AQD

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During the 1987 Aquaculture Development in Southeast Asia (ADSEA) Conference, member countries of the Southeast Asian Fisheries Development Center (SEAFDEC) recommended *Gracilaria* as the number one priority for seaweed research in the following areas: 1) refinement of culture techniques, 2) basic biology, 3) product utilization, and 4) screening and characterization of natural products. However, three years later, *Kappaphycus* was also included as priority research in answer to the needs of the industry.

As an initial action to the above mandate, an inventory of the seaweed resources of Panay was made to determine the distribution and taxonomy. As a result of this activity, a monograph was published by Hurtado-Ponce et al. in 1992. This monograph describes 114 species that include 38 Chlorophyceae, 21 Phaeophyceae and 55 Rhodophyceae. There were 37 species considered as new record for Panay (Luhan et al. 1992). But a revision of this monograph is imperative to determine possible changes in the distribution of the seaweed resources brought by some ecological alterations. Collection of seaweeds around Panay is in progress.

Preliminary screening of the different *Gracilaria* species *(G. arcuata, G. changii, G. coronopifolia, G. eucheumoides, G. firma, G. heteroclada* (= *Gracilariopsis heteroclada), G. manilaensis, G. salicornia,* and *G. tenuistipitata)* in Panay revealed that among the species tested for growth and agar characteristics, *G. heteroclada* showed the best qualities, hence, research and development of this species were further pursued.

There are several accomplishments on seaweed research along these areas:

Production ecology

The reproductive state of *Gracilariopsis heteroclada* is known to be seasonal, the carposporophytes ad tetrasporophytes being high in January (48%) and May (64%), respectively. The results suggest that gathering of natural stock prior to maturity is not advisable.

Likewise, there was seasonality on the year-round biomass of *G. heteroclada* in Jaro, Leganes, Zarraga, Estancia, Iloilo; Ivisan, Capiz and Batan, Aklan (de Castro et al. 1991, Luhan et al. 1992). On the other hand, *G. manilaensis* (April-June) and *G. changii* (January -June) were found to occur only during certain months of the year; that simply means that these seaweeds are dormant during the rest of the year (Pondevida and Hurtado-Ponce 1996). Apparently, salinity is a critical factor for growth and biomass production.

Physiology

Sporelings from fertile cystocarp plants of *G. changii, G. coronopifolia, G. firma* and *Gracilariopsis bailinae* were grown in the laboratory to document their life stages for future molecular studies. Furthermore, viability of sporelings grown under laboratory condition was observed and use for possible outplanting will be tested by MRJ Luhan (pers.com.).

Crop management

The amount of biomass left after the first cropping or gathering of *G. heteroclada* is important in determining the amount of biomass available for the next cropping season. Among the 4 levels of harvest (25, 50, 75 and 100%), 75% provides the appropriate amount of 'seeds' for the next cropping season. The amount of biomass to be harvested during each harvest regime should exceed the amount of biomass available for cropping (Hurtado-Ponce 1993)

Corollary to the above scheme, the use of harvesting tools is also critical in managing the biomass. The use of 'araña' is efficient in areas where there is water during harvesting since it facilitates the dragging of the tool. It leaves a certain amount of biomass (75%) for the next cropping or gathering. However, the use of a rake is very detrimental to the biomass, since it leaves nothing for the next cropping and it takes almost 3 months for the seaweed to regenerate. The use of a pair of scissor and bare hands as tedious and brings a lot of trampling to the substrate, thereby resulting to excessive disturbances and slow recovery of the seaweed.

Farming systems

Tank cultivation. Gracilariopsis heteroclada was studied under tank conditions to determine salinity tolerance, nutrient assimilation (quantity and quality), water exchange and stocking rate. Optimum growth of *G. heteroclada* was obtained at 25 ppt, 500 gm^{-2} stocking rate, water exchange.

Two varieties of *Kappaphycus alvarezii* were studied under tank conditions to determine variations in growth rate, pigments and carrageenan qualities as influenced by different levels of ammonium sulfate as source of nutrient. No significant difference was analyzed between the varieties, but there were significant differences between levels of nutrients and culture period in terms of growth rate, pigments (chl-a, R-PE), carrageenan yield, gel strength, gelling and melting temperature and sulfate content.

Line cultivation. Fixed-off bottom line of cultivating *G. heteroclada* in estuaries showed promising results. Growth rate of 6.7%/day was obtained, suggesting its commercial potential. The constant replenishment of nutrients during spring tide makes the area suitable for culture purposes (Hurtado-Ponce et al. 1997).

The seasonality of two varieties of *K. alvarezii* grown in fixed off-bottom line, hanging long line and a combination of the two methods showed lowest and highest growth rates and yields from July to August and January to February, respectively.

Cage cultivation. The monoculture of *G. heteroclada* using vertical lines at 10 cm interval showed significant growth over those cultivated at 15 and 20 cm interval (Hurtado-Ponce 1990), while the polyculture of the same seaweed with seabass, *Lates calcarifer* proved to be encouraging since high growth rate and production were obtained from the seaweed and seabass, respectively (Hurtado-Ponce 1992).

The broadcast method of culturing *G. heteroclada* in hapa net installed in floating cages showed significant growth and net production during the dry season (Guanzon and de Castro 1992) when grown at different stocking densities.

Results on the mono-and polyculture of *Kappaphycus alvarezii* were encouraging. Among the 3 morphotypes (brown, green and red) of *K. alvarezii,* brown and green gave better growth rates results.

K. alvarezii, when cultured using the horizontal line with grouper, *Epinephelus* sp. showed better growth rate (5.3% day^{-1}) than when cultured using the vertical and cluster technique. After 120 days of culture, 68% of the grouper survived and reached mean weights of 297 g.

The use of growth hormone (IAA) alone in culturing *K. alvarezii* in tanks showed comparable growth with those grown with ammonium phosphate. When the same plants were outplanted, growth of *K. alvarezii* was slightly better (7.1-7.5%) when grown in higher combination levels of ammonium phosphate/IAA (10/1 and 10/5 mg L^{-1}) than in lower combination levels (5/1 and 5/5 mg L^{-1}; 6.8-6.5%). The addition of ammonium phosphate appears more practical than the addition of IAA, a plant growth regulator, because the latter is expensive (Fermin and Hurtado 2001).

Pond cultivation. Polyculture of *Penaeus monodon* and *G. heteroclada* showed good growth at a stocking 5,000 ha^{-1} and 2,500 kg ha^{-1}, respectively when the water temperature was 29.5° C, 24 ppt, transparency of 74% and water depth 83 cm.

Colloid characterization

Several studies were made on the characterization of agar from different species of wild *Gracilaria* in Panay. Results show that each species produce quality agar as influenced by concentration and time of NaOH treatment (de Castro 1993, Luhan 1992). *Gracilariopsis heteroclada,* both cultured in tanks and brackishwater ponds demonstrated superior qualities compared to the species collected from natural population (Hurtado-Ponce 1994, de Castro 1996, Pondevida and Hurtado-Ponce 1996b, Hurtado-Ponce and Pondevida 1997)

The quality of agarose extracted from wild populations of *G. bailinae* showed significant seasonality in yield and gel strength, however, gel strength was inversely proportional to the agar yield. Water temperature, turbidity and pH exhibited no significant correlation with gel properties, however, a slightly positive correlation existed between agarose yield and salinity.

Gel strength of brown and green strains of *K. alvarezii* varied seasonally when grown by fixed off-bottom long line, hanging long line and a combination of the two cultivation methods, however, a higher gel strength was recorded when *K. alvarezii* was grown by a HL-FB method compared with those grown by the two other methods.

The carrageenan properties and pigment levels of two varieties of *K. alvarezii* grown in tanks at different levels of ammonium sulfate as nutrients were studied. Significant differences in growth rate, R-PE, and gel strength were determined between the two varieties as influenced by the levels of ammonium sulfate. Significant differences were detected between the two varieties in terms of carrageenan yield, gel strength, gelling and melting temperatures and sulfate content (Gonzales 1996).

Economics

The economics of cultivating *Gracilaria* and *Kappaphycus* both experimental and actual inputs were analyzed using economic indicators like return on investment (ROI) and payback period. Results showed that farming these seaweeds using the line method, fixed off-bottom, raft (single or multiple) and hanging long line are all profitable, however, production is affected by environmental conditions (typhoon, salinity-temperature) and fluctuating farmgate price (Hurtado-Ponce et al. 1992, 1996 & 1997, Hurtado and Agbayani 2000, Hurtado et al. 2001).

Biotechnology

Young plantlets of *Eucheuma denticulatum* that regenerated from tissue culture after 6 months of laboratory culture resembled wild plants. After 3 months of field growth, the plants were potential sources of 'seedlings' for further planting purposes.

Analysis of molecular variance (AMOVA) suggested that there were significant genetic differences ($P<0.001$) among *E. denticulatum* plants derived from tissue culture, wild *E. denticulatum,* and cultured *K. striatum.* The same analysis also indicated that *E. denticulatum* plants regenerated from calli were genetically distinct ($P<0.001$) from those derived from calli, in which random variation was induced by acute exposure to sublethal amounts of UV radiation.

Techniques on mass production of sporelings from carpospores were established under laboratory conditions in some *Gracilaria* species *(G. firma, G. coronopifolia* and *G. heteroclada).* Protoplast production of the same species is presently pursued.

Polymorphic DNAs are high resolution genetic markers, which can be used to characterize or differentiate various species, strains or populations of seaweed. In the laboratory, polymorphic DNAs, such as RFLPs and RAPDs are being generated to characterize strains of wild and cultured populations. A series of 40 arbitrary primers were screened for ability to generate distinct and highly polymorphic fragments from *G. coronopifolia.* Primers A1, B1Q, B12 and B14 were selected to generate RAPDs for various seaweed species. Discrimination between species was possible with primers B10, B12 and B14. *G. coronopifolia* and *G. firma* share similar Al-primed RAPDs.

Sequestration of heavy metals (Cd, Cu, Pb, Zn) by *G. heteroclada* is directly proportional to the level of concentration and time of exposure. It was shown that heavy metals were retained in the tissues and in the extracted colloid in this order (Cu > Zn > Cd > Pb).

Gracilariopsis bailinae is a good biofilter in an integrated culture system of finfish broodstock. Ammonia concentration in tanks with seaweed was lower than in tanks without seaweed. Nitrogen in the tissue of *G. bailinae* became saturated after five days of culture, suggesting that growth was initiated upon saturation of nitrogen pools in the plant tissue (Luhan, unpublished).

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Workshop Outputs

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
CAULERPA				
Production				
Lack of proper management of natural stocks	Management of natural stocks	DA, BFAR, NFRD1 Regional Offices, MSU Tawi-Tawi, MMSU, ZSCMST, UP-MSI	DA, BFAR, BAR	2002-2004
Culture system for *Caulerpa racemosa*	Rice planting style (fish pond), basket type for seedling bank. Transfer/ adaption of existing farming, culture technologies. Water management studies, to improve culture & farming systems.	DA,BFAR,ZSCMST, MMSU, MSU Tawi-Tawi, USC, NSTDC-BFAR,UP-MSI	DA, BFAR, BAR	2002-2004
Lack of raw materials	Establishment of nursery farm for seedling dispersal. Management of natural stocks.	DA,BFAR,MSU Tawi-Tawi, UP-MSI, MMSU.ZSCMST	DA, BFAR, BAR	2002-2004
Post Harvest				
Lack of information on post-harvest techniques	R&D	DA.BFAR/UPV.DOST	AFMA,DA,BFAR	2002-2004
Poor handling facilities	Development of appropriate handling technologies.	UPV, MMSU	AFMA, DA, BFARI	2002-2004
Microbial contamination of *Caulerpa* (coliform)	Establishment of protocol for the monitoring of environmental safety.	UPV, DOST, DENR-EMB, BFAR	AFMA.DA.BFAF	2002-2004
Processing				
Lack of technologies for processing	Improvement of existing technology for processing quality product. Assessment of salt concentration used.	UPV, BFAR, UP-MSI, MMSU, MSU Tawi-Tawi	AFMA, BAR	2002-2004

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Inappropriate packaging materials	Development of suitable packaging material	UPV, BFAR, DOST-ITDI	BAR, PCAMRD	2002-2004
Weak information or dissemination system	Development of information and educational materials	UPV, BFAR	BAR, DOST	2002-2004
Poor quality of finished product	Quality assurance program (HACCP)	UPV, BFAR	DOST	2002-2004
Markets				
Fluctuating price	Improvement of marketing strategies for small producers	UPV	DA-AMAS	2002-2004
Buyers	Market matching	UPV	DA-AMAS	2002-2004
Socioeconomics	Assessment of the role of women in the seaweed industry	UPV-CFOS	DA-AMAS	2003-2005
GRACILARIA				
Production				
Limited farming information	Develop farming techniques for land-based and coastal areas Develop farming techniques for land-based and coastal areas	BFAR, SEAFDEC, UP-MSI, MSU TawiTawi, & SUCs, Academe	BFAR, SEAFDEC, GEM, SIAP	2ND QTR 2002- 2005
Lack of seedlings	Identify sources of seedlings Improve strains. Establishment of seedling banks, nurseries and gene banks	ZSCMSTBFAR, SEAFDEC, UP-MSI, MSU Tawi Tawi and SUCs	BFAR, SEAFDEC, GEM, SIAP, DA-BAR, DOST, PCAMRD	2ND QTR 2002-2005
Limited info on seasonality and maturity	*Gracilaria* stock assessment			2ND QTR 2002-2005
Disease and other malaise (grazing epiphytism, parasitism)	R&D on disease identification, prevention and control	BFAR, SEAFDEC, UP-MSI, MSU Tawi Tawi and SUCs	BFAR, SEAFDEC, DA-BAR, DOST, PCAMRD	2ND QTR 2002-2005

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Presence of pollutants and contaminants (agricultural, industrial, and domestic wastes	R&D on identification and evaluation of pollutants and contaminants	BFAR, SEAFDEC, UP-MSI, MSU Tawi-Tawi and SUCs, DENR	BFAR, SEAFDEC, DENR, FDC	2ND QTR 2002-2005
Post Harvest				
Lack of postharvest facilities (drying platforms and storage)	Establishment of post-harvest facilities in *Gracilaria*-producing areas	BFAR, SEAFDEC, UP-MSI,MSU Tawi-Tawi and SUCs,	BFAR, SEAFDEC, GEM, SIAP	2ND QTR 2002-2005
Quality assurance service facilities/equipment determination of moisture, heavy metal content, agar quality, impurities (salt, sand and debris), microbiological contamination	Establishment of quality assurance service facilities in the identified areas	BFAR and DOST Regional Satellite Centers	BFAR, DA, DOST, JICA	2ND QTR 2002-2005
Processing				
High production cost	Develop techniques and methods to reduce operational costs Establishments of processing plants in strategic areas	SIAP, Processors, DOST-ITDI	SIAP, PROCES-SORS	2ND QTR 2002-2005
Contamination due to handling, microorganisms, equipment and water and air pollutants	Establishment of quality assurance service facilities	DOST, BFAR	DOST, BFAR, DA-BAR	2ND QTR, 2002-2007
Non-compliance of environmental requirements	R&D on the effect of processing wastes on the environment Environmental monitoring and evaluation of waste material from seaweed processing. Waste management	DENR-EMB,LGUs, BFAR	DENR, EMB, BFAR, LGUs	2ND QTR, 2002-2007

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Product development and application				
Lack of technical personnel	Conduct training on product development and application	UP-MSI, ITDI, NSTDC-BFAR, UP, CHED	BFAR, DOST	2^{ND} QTR, 2002-2007
Lack of understanding of the properties of the product	Information dissemination thru production of leaflets, primers, posters, etc.	DOST, DTI, PCAMRD, BEAR	PCAMRD, DOST, BFAR, DTI	2^{ND} QTR, 2002-2007
Lack of access to state of the art equipment, references and other info	Establishment of regional testing centers Provide internet access and published popularized information as in (B)	BFAR and DOST Regional Satellites	BFAR & DOST	2^{ND} QTR, 2002-2007
Limited product diversification	R&D	UP-MSI, DOST& FNRI, ITDI	BFAR, DOST, NEDA	2^{ND} QTR, 2002-2007
Other uses of *Gacilaria* and *Gracilaria* waste products	R&D: biofiltration, bioremediation, aquaculture/poultry feeds, organic fertilizer, agriculture, paper products, microchips, fuel, natural products, pigments, non-food additives	UP-MSI, MSU Tawi-Tawi, SUCs, SEAFDEC, BFAR-NSTDC,ITDI	BFAR, DOST, DA-BAR, PCAMRD, SEAFDEC, DTI	2^{ND} QTR, 2002-2007
Markets				
No national standards for dried raw material and agar	Create national standards for dried *Gracilaria* and agar	BPS,UP-MSI,BFAR, SIAP, MSU Tawi - Tawi, SEAFDEC, Processors	BPS	2^{ND} QTR, 2002-2007
Limited market info and promotion	Information dissemination through media & print	TAPI, TLRC, PCAMRD, BAR, DTI	PCAMRD, TLRC, TAPI, BAR	2^{ND} QTR, 2002-2007
Lack of minimum buying price	See pricing scheme for *Eucheuma*	DTI	DTI	2^{ND} QTR, 2002-2007
High transport and handling cost	Establishment of regionalized buying stations	BFAR, DOST, LGUs	DA, BFAR, DOST, LGU	2^{ND} QTR, 2002-2007

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Socioeconomics				
Labor disputes. Lack of cooperation among processors and traders	Organize traders and processors into an association	SIAP	SIAP	2ND QTR, 2002-2007
Worse peace and order situation in some areas		AFP, PNP, LGU	AFP, PNP, LGU	
Financing				
Stringent financing requirements	Soften the funding requirements	Banks, Quedan Cor, Landbank		2ND QTR, 2002-2007
KAPPAPHYCUS				
Production				
Lack of seedlings	Establishment of seaweed nurseries (ocean-based) • Regions 4, 7 & 8 • Other Regions	BFAR	BFAR	 2000 2001-present
	Establishment of seaweed nursery (land-based and ocean-based)	BFAR, SEAFDEC, SIAP	BAR	
	Development and establishment of gene bank, seedling bank and tissue culture bank	UP-MSI, SEAFDEC, SIAP	USAID	1991-1994(?)
Low quality seedlings	To conduct R&D studies on: • Development of cultivars from spores (through sexual and asexual reproduction) • Development of resistant/improved strains through protoplast fusion, mutation, DNA recombination, etc.	UP-MSI, SEAFDEC, MSU, DOST, SIAP, NGOs	USAID through GEM	1995-1997(?) 1999-(not completed)
Diseases and other malaise in farms	Field monitoring of environmental factors in farms *vis-a-vis* occurrence of disease	UP-MSI, BFAR, SIAP, NGOs.USCs	BAR	2000-2002

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
	Train personnel on monitoring of factors and implementation of mitigating strategies			
	Conduct R & D studies related to occurrence of the disease (effect of ecological factors, bacteria, etc.) and its effect on carrageenan quantity and quality			
Low quality seaweed produce	Primer?			
Farming Method/ Farm structures	Undertake R & D on adapting available materials or developing new ones; aquaculture design/ structures engineering; durable materials	SCUs, SEAFDEC GEM, BFAR	BAR, PCAMRD	2002-
Post Harvest				
Lack of post-harvest drying platforms and storage (warehouse)	Provision of post-harvest facilities (stilt dryer/solar dryer)	BFAR, BPRE, NGO	BFAR	2000-
	Identification of beneficiaries			
Lack of quality assurance service facilities/equipment	Information dissemination	DOST		
Processing				
High seaweed prices for low quality produce (high moisture content, low carrageenan content, low CAW)	Setting up of quality assurance facilities/ equipment in strategic areas.	DA-AMAS, BAFPS, BFAR, FDC, SIAP, DTI-BPS, DOH-BFAD, DOST, UP-MSI		First half of year 2002

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
	Create dried seaweed classification with corresponding price bracket based on seaweed quality (to be included in the proposed Code of Practice)			
	Push for the revision/ updating of the current Product Standards to include specifications for processed products (RC and SRC-pet food and food grade). Revision and review must be publicly heard			
	Popularization of Product Standards, i.e. translation of guidelines into local dialects			
	Formulate specifications for dried seaweed and forge for its strict implementation			
Non-compliance to environmental requirements	Promote ISO 14000/ Environmental Management System to the Industry	DENR, SIAP		
Non-tariff barriers	Link/coordinate with CCFAC, JECFA and Codex Alimentarius on the establishment of acceptable food additive standards	SIAP, DA, UP-MSI, DTI, FDC		
	Lobby for the creation of less stringent or reasonable standards			
	Conduct industry surveys to establish acceptable levels of food additive standards			

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Product development and application				
Lack of state of the art equipment and access to references and other information	Source for funds for procurement of state of the art equipment	DA-BFAR, UPV DOST, UP-MSI, SIAP		
	Establish linkages/ networking with concerned institutions for references and new information			
Lack of technical personnel, and understanding of properties of the products	Conduct trainings/ formal and informal education of technical personnel	UP-MSI, SEAFDEC, BFAR, SIAP		
	Conduct and implement R&D studies on the properties of the products			
	Undertake seminars to disseminate results of R&D projects			
Markets				
Lack of minimum buying price	Formulate mechanisms on price setting acceptable to stakeholders	SIAP, Gov't Agencies to assist DA-BFAR, DTI, LGUs		
High transport and handling costs	Policy advocacy to improve port/shipping and handling operations	PPA, MARINA, GEM		
	Construct additional infrastructure support facilities			
Limited market information and promotion, both local and abroad	Promote the Philippines as the seaweed/ carrageenan supplier by: • inducing seaweed/ carrageenan exporters to participate in DTI's Tradeline	BETP, SIAP		

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
	• promoting e-commerce to industry players	SIAP		
	• conducting seminars on e-commerce for industry players	DTI, BETP		
	For GEM to provide computers/internet facilities to Western Mindanao Seaweed Council	GEM	GEM	
	Install SIAP website through Yahoo or AOL for faster access	SIAP		
	Publish articles on success stories of carrageenan processors/seaweed farmers on major dailies at least once a month	BETP, SIAP, DTI-PRO		
	Market carrageenan to users of new applications by product launching, business matching and outgoing selling missions	BETP, SIAP		
	Prepare updated and accurate SIAP catalogue of member companies and their products to be disseminated to clients, trade promotion agencies and trade attaches	BETP, SIAP, FTSC		
	Maintain/improve competitiveness *vis-a-vis* competitor suppliers by improved packaging of export products	BETP, SIAP, PDDCP		
	Set-up a nationwide price info and a monitoring system by radio	SIAP, DA, DTI, GEM		

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
	Monitor development in export market (e.g., competitor moves re: lead content)	TWC, SIAP, FTSC		
	Conduct Phil. seaweed/ carrageenan industry situation study	GEM		
Socioeconomic				
Resource-use conflict	Zoning of seaweed farming areas	LGU, BFAR, DENR		
Financing				
Stringent financing requirements	To make a request to the banks to ease their lending requirements	SIAP, BFAR		
SARGASSUM				
Production				
Limited population management scheme	More R&D studies on sporelings	Academe - SUCs ZSCMS, UP-MSI, USC, PNAC, SEAFDEC, MSU, MMSU, DA-BAR, BU, SIAP	DA SEAFDEC, DOST-PCAMRD, DA-BFAR, FAO, GEM, SIAP, JICA	2002-2007
Lack of natural recruitment studies and transplantation studies	More R&D studies on natural recruitment and transplantation			
	More R&D on stock enhancement			
Poor harvesting techniques	Information dissemination and demonstrations			
Post Harvest				
Limited R&D studies on storage techniques for alginate production	More studies on storage techniques for alginate production	Academe-SUCs ZSCMST, UPMSI, USC, PNAC, SEAFDEC, MSU, MMSU, DA-BAR, BU, SIAP, DOST-ITDI,	DOST, DA-BAR, SEAFDEC, FAO	2002-2007

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
		DOST-PCAMRD, DOST Reg. Offices		
Lack of drying/storage facilities	Establishment of drying/ storage facilities and equipment for quality assurance of the product			
Lack of quality assurance service facilities/equipment - moisture - heavy metals - impurities - alginic acid/alginate content				
Processing				
High production cost for alginate	More R&D studies for economically viable processes for alginate	Academe-SUCs SEAFDEC, MMSU, DOST-ITDI, PTRI, S1AP	DOST, DA, SEAFDEC, FAO	2002-2005
Product development and application				
Lack of technical personnel	More R&D activities on product development, e.g. aquaculture feed and other uses	Academe-SUCs UP MSI, MMSU, DOST-ITDI, PTRI, SIAP	DOST, DA, FAO, JICA	continuing
Lack of product diversification				
Lack of SOA equipment/access to references and other information				
Lack of technical know-how on the properties of the product				
Markets				
Lack of minimum buying price	Create a mechanism to address the issue of minimum buying price (e.g. Code of Practice for the Seaweed Industry)	All stakeholders	SIAP, GEM, DTI, DA-BFAR, and other concerned agencies	continuing

Workshop output (continued)

Problems	Strategies	Lead Agency	Funding Agencies	Time Table
Limited market information, local	Improve market promotion/information thru lectures/ seminars for farmers and processors w/ emphasis on ecological importance of *Sargassum*	Univ. of Asia and the Pacific, PDIS-NEDA, DTI(BOI, CITEM), SIAP, UPISSI		
Limited market promotion, local				

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Appendix

List of acronyms

AFMA	Agriculture and Fisheries Modernization Act
BAS	Bureau of Agricultural Statistics
BETP	Bureau of Export Trade Promotion
BFAR	Bureau of Fisheries and Aquatic Resources
BOI	Board of Investment
BU	Bicol University
CITES	Convention on International Trade and Endangered Species
DA-AMAS	Department of Agriculture-Agribusiness and Marketing Assistance Service
DA-BAR	Department of Agriculture-Bureau of Agricultural Research
DENR-EMB	Department of Environment and Natural Resources-Environment Management Bureau
DMMSU	Don Mariano Marcos State University
DOST	Department of Science and Technology
DTI	Department of Trade and Industry
FAO	Food and Agriculture Organization
FDC	Food Development Center
GEM	Growth with Equity in Mindanao
IDRC	International Development and Research of Canada
ITDI	Industrial Technology Development Institute
JICA	Japan International Cooperation Agency
MARINA	Maritime Industry Authority
MMSU	Mariano Marcos State University
MSRI	Marine Science Research Institute
MSU	Mindanao State University
NEDA	National Economic Development Authority
NSTA	National Science and Technology Authority
NSTDC	National Seaweed Technology and Development Center
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PNAC	Palawan National Agriculture College
SDP	Seaweed Development Plan
SEAFDEC	Southeast Asian Fisheries Development Center

SGV	Sycip Gorrez Velayo
SIAP	Seaweed Industry Association of the Philippines
SICEN	Seaweed and Invertebrate Information Center
SUC	State Universities and Colleges
TAPI	Technology Application and Promotion Institute
TLRC-NFRDI	Technology and Livelihood Resource Center - National Fishery Research and Development Institute
TWC	Technical Working Committee
UNDP	United Nation Development Program
UP-MSI	University of the Philippines-Marine Science Institute
USC	University of San Carlos
ZSCMST	Zamboanga State College of Marine Sciences and Technology

The Southeast Asian Fisheries Development Center (SEAFDEC) is a regional treaty organization established in December 1967 for the purpose of promoting fisheries development in the region. Its member countries are Japan, Malaysia, the Philippines, Singapore, Thailand, Brunei Darussalam, the Socialist Republic of Vietnam, Union of Myanmar, and Indonesia.

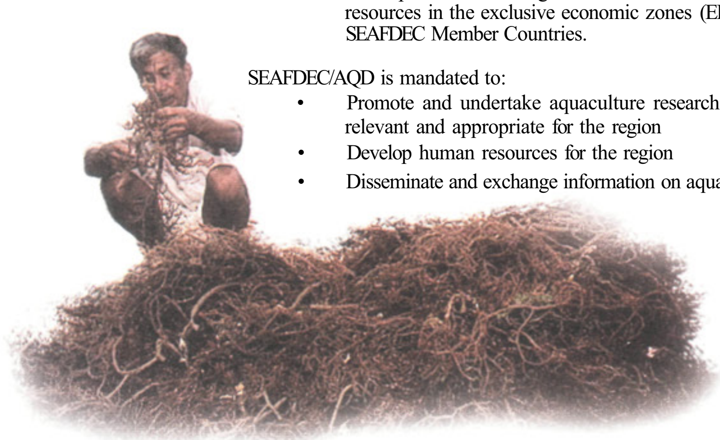
Representing the member countries is the Council of Directors, the policy-making body of SEAFDEC. The chief administrator of SEAFDEC is the Secretary-General whose office, the Secretariat, is based in Bangkok, Thailand.

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 were 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
- The Marine Fishery Resources and Development and Management Department (MFRDMD) in Kuala Terengganu, Malaysia, established in 1992 for the development and management of the marine fishery resources in the exclusive economic zones (EEZs) of SEAFDEC Member Countries.

SEAFDEC/AQD is mandated to:

- Promote and undertake aquaculture research that is relevant and appropriate for the region
- Develop human resources for the region
- Disseminate and exchange information on aquaculture



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