SEMINAR PAPERS: SESSION IV
MANAGEMENT OF NATURAL RESOURCES OF AGAROPHYTES

MANAGEMENT OF NATURAL RESOURCES OF TROPICAL AGAROPHYTES

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ABSTRACT

This paper deals with considerations on management and utilization of natural stocks of seaweed for commercial exploitation. Emphasis is laid on intensive biological studies to determine seasonality in biomass production, reproduction, regeneration, recruitment, abundance and distribution. Strict application of a management scheme will help improve the production ecology of a given seaweed bed.

1. Introduction

The production of agar-producing seaweeds comes from three sources, namely gathering of drift materials, direct harvest from natural stocks and cultivation. At present, the bulk of the seaweeds used for agar manufacture still comes from harvested natural stocks. There are no available and accurate data on the contribution of agarophytes produced through culture, but judging from the genera presently produced in different countries, which were imported by Japan in 1984 (Armisen and Galatas 1987). about 50% of the raw seaweeds presently processed into agar still come from natural stocks. The genera presently utilized in the international market for agar production are *Grucilaria, Gelidium, Pterocladia, Gelidiella, Anfheltia* and *Ceramium.*

Approximately 6,683 tonnes of agar were produced by 14 countries in 1984 (Armisen and Galatas 1987). Of this, about 48% was processed from *Gelidium* and *Pterocludia* with the remaining 57% from "other seaweeds" which undoubtedly include genera such as *Gelidiella* and *Gracilaria.* As far as *we* know today, only the genus *Gracilaria* is presently produced in commercial quantities through cultivation. In the first half of the 1980s, Chile, Brazil, Taiwan and Philippines were the main suppliers of cultured *Gracilaria* to Japan. Recently, Vietnam, Indonesia, Thailand, Hawaii and others have applied culture techniques in *Gracilaria* production. At present, however, a large proportion of the *Gracilaria* produced still comes from local stocks. *Gelidium* and *Pterocladia,* utilized mainly for the manufacture of bacteriological agar and agarose, come so far as we are aware, from the gathering of natural stocks. Their commercial production through farming seems to be still a long way from realization. Thus, the production of most of these agarophytes is expected to be dependent on their natural stocks for a long time to come.

2. important considerations in the utilization of natural stocks as a source of biomass

The production of agarophytes from natural stocks is very much influenced both by seasonal factors and by harvest pressures exerted on them during the preceding cropping season. Because their growth cycles are greatly influenced by environmental conditions and by man's exploitive activities, their production is unreliable. They are prone to over-exploitation, and the need to manage and conserve their stocks is of prime importance in order to sustain or further enhance their productivity and prevent over-exploitation.

The design of a sound management scheme for the natural stocks of commercial agarophytes depends primarily on the availability of information on the various aspects of their biology, such as reproduction and growth cycle, growth rates, their regeneration and recruitment capacities, their productivity and the influence of environmental factors on the biomass production potential of the stocks. This information is necessary to formulate guidelines for managing the natural stock of the target species. The information can provide answers to questions such as where the species is abundant, how much to harvest per unit area, when to harvest, how many times (cropping intervals) the stocks can be harvested in one season and what kind of harvest method is best for the species. Gathering such information on the species to be managed requires basic skills in field sampling and data gathering. Under management. the production of stocks can be forecast with confidence. This information is most important for quoting in contracts which may be entered into by the farmer, fisherman. or exporter.

It is therefore of prime importance that any plan to exploit natural seaweed stocks be preceded by intensive biological studies to determine their seasonality in biomass production, reproduction, regeneration and recruitment. This information is necessary for determining the best possible time to harvest, and the amount of stocks harvestible, without diminishing their production capacities.

3. Requisites to the rational exploitation of natural stocks

In a "free-for-all" situation, there is always a natural tendency for resource users to over-exploit resources, especially where there is a prevailing demand for the produce. The literature is replete with records of resource losses due to over exploitation. Thus, it is necessary that the commercial exploitation of natural seaweed stocks, or any resource, be preceded by biological studies which shall be the basis for their management.

3. I Inventory and assessmentof stocks

The inventory and assessment of stocks are initial studies which should be done in areas where the exploitation of stocks has not yet started. This will identify the species potentially available for development, where and when these species are abundant, how much biomass is available for harvest and the behaviour and responses of the stocks to certain degrees of exploitation.

The need to know the true identities of the different species is very important because unlike other resources, e.g., fish and crustaceans, the kinds and quality of agar vary from species to species. Thus, it is very important that the taxonomy of the species comprising the stocks is known. In addition, the quality of the hydrocolloid (agar) should be defined, characterized or evaluated as the price of the produce is determined by the quality of its extractable agar. In the world agar market, the name of the species and, in the case of ***Gracilaria,*** information on the source of the dried raw material, .are important because they reflect the differences in the properties of the agars. ***Gracilaria*** from Chile, for instance, fetches a higher price than that from the Philippines because it contains higher quality agar. Thus, the names applied to these produce serve as a basis for their pricing. The price is generally based on the moisture content and the purity and quality (gel strength, melting and gelling temperatures, viscosity and amount of sulfate group) of the agar.

Information on the abundance and distribution of the resource in space and time may be gathered through biomass samplings of the stocks. The application of available methodologies may differ slightly, depending on the behaviour of the resource. However, the transect quadrat method is widely used especially **in** situations where stocks are not homogeneously distributed in space. The size of the bed is first delineated and permanent transects are marked. The orientation of the transects is generally related to certain ecological gradients, such as depth and wave exposure. Biomass samplings are generally done on a monthly basis along the transects; the size of the quadrat varies from 0.25-1.0 m^2. The number of quadrats to be sampled along the transects may also vary, depending on the size and homogeneity of the bed, the time and effort required but most important is the amount and type of data for statistical analysis i.e. the more the samples that are gathered, the more reliable the data **will be.**

The amount of loose (drift) biomass should also be monitored to derive reliable data on the total biomass production of the bed.

Data on biomass production recorded for a period of one year will indicate the annual productivity and seasonality in production of the stocks. Additional data from following years will make the information on the stocks more reliable as a basis for management. In most stock assessment studies where the target species or group of species and their distribution are known, the main concern is the determination of production data.

The size of the bed must be known so that the potential total production of stocks can be determined. This information is vital in determining how much of the stocks should be harvested without unduly diminishing their productivity. Using the production data from the samples, total production of the bed may be projected/calculated by multiplying the biomass data (g/m^2) by the size of the bed. The accuracy of the method is much improved if regular and repeated samplings of the stocks are carried out.

Additional information on production in the area can be gained through interviews with market vendors and seaweed gatherers. Initial interviews may be done in local open markets where seaweeds are sold. Seaweed vendors are a good source of information on the kinds of species, the amounts they sell, the sources of seaweed stocks, suppliers and the approximate number of gatherers. Seaweed gatherers are good sources of primary data on production. They can easily be identified by inquiring from local officials in the area. Data on gathering sites, number of gatherers, the gathering season and output per unit effort may be acquired from this source. An estimate of local production can then be made, and counter-checked with the data on potential biomass production of the beds or collecting area.

The seasonal variation in the reproductive/fertility states of the stocks should also be known. The fertility of the stock may be determined by randomly collecting 50 or more thalli and determining the number which are vegetative and fertile. This is usually expressed as % fertility. This information is relevant in the scheduling of harvesting/cropping periods. The recruitment capacities of stocks is generally influenced by their states of fertility, especially for those species where recruitment is largely dependent'on the production of reproductive cells (spores). Cropping or harvesting should be scheduled some time before or after the peak of fertility of the stocks, in order not to interfere unduly with the recruitment process. This, however, may not be relevant to species where production is based mainly on vegetative means (cuttings, fragments). Some stocks of Gracilaria, for instance, have been reported to be purely vegetative (Rueness et al. 1987). Pond cultured ***Gruciluriu*** have been observed to be purely vegetative the whole year round in Northern Philippines (personal communication). In cases where recruitment is primarily based on vegetative means, a certain amount of the seedstock is retained in the bed for the next season's croppings. This amount may be equivalent to the amount of biomass produced in the bed during its lowest production period.

In addition to these basic biological studies, harvesting experiments should be carried out to determine the production capacities and the effects of different harvest pressures and methods on the regeneration of the stocks. The information on the capability of the stocks to regenerate to their former level of production after trial cropping/harvesting shall be the basis for determining the harvest schedules during the cropping season.

3.2 Development and application of a management scheme for the stocks

The application of a management scheme to natural stocks has been shown to significantly improve the total production of the beds. In Chile, the annual production of Gracilaria in Lenga Cove located in San Vicente Bay increased from 80 tonnes to 600 tonnes after the application of a management programme (Poblete and Inostroza. 1987). It is apparent from their studies that the strict application of a management scheme had improved the production ecology of the bed, resulting in an increase of seven and a half times its normal production.

In general the formulation and application of a management scheme for the natural stock of seaweeds may follow the following steps. Variation from this scheme may be necessary to suit certain biological characteristics of the species concerned. The basic considerations are:

a) Seasonal changes in the annual productivity of the stocks.

Data on changes in the annual productivity of the stocks are derived from the monthly biomass measurements done on the bed. They provide information on the total amount of biomass available for cropping, and the season when cropping/harvesting may be done. In addition, the seasonal variation in the amount of agar contained in the crop is also considered in the scheduling of the harvest. A high quality crop is obtained when harvesting is done during periods where the agar content is high.

b) Determination of the amount of biomass to be left after cropping.

The amount of biomass left after the first cropping is very important in determining the amount of biomass available for the next cropping season. As a "rule of thumb," the minimum amount to be left in the bed to serve *as* "seeds" for the next cropping season should not be less than the lowest biomass recorded during the year. The amount of biomass available for harvest will be the difference between the total amount available in the bed during its peak production period and the minimum biomass during its period of depressed growth.

c) Determination of the harvest schedule.

How often should the harvest be done during the peak production season? The harvest regimes can be determined from information on the regenerative capacity of the stocks, e.g. from the results of studies on different trial harvest pressure. The schedule of subsequent harvests is determined by the period within which the stock can recover its original biomass after the first harvest.

d) Control of the amount of biomass to be harvested.

The amount of biomass to be harvested during each harvest regime should not exceed the amount of biomass available for cropping. It is, therefore, necessary that the number of fishermen should be limited, and that the amount of crop each is allowed to harvest must not exceed his share of the biomass available for cropping during each of the cropping periods.

e) Protection of the recruitment and regeneration processes.

This is a very important consideration because the continuity of the stocks depend on these processes. The approach may differ depending on the biological characteristics of the species. For stocks which depend on the regeneration of biomass through vegetative structures such as holdfasts, cuttings or fragments, and underground thalli, protection may be ensured by the application of harvest methods which cause the minimum harm to these regenerative structures. For stocks whose recruitment and regeneration processes depend both on reproductive cells and vegetative structures, the timing of the harvest so as not to impede or adversely affect recruitment and the use of harvest methods which have minimal destructive effects on the regenerative structures are important considerations. Thus, harvesting should not be done during peak fertility of the stocks.

f) Socio-economic considerations in managing the resources.

The fishermen/seaweed gatherers should be organized into production groups such as cooperatives. Only bonafide members have the right of access to the resource, and the amount each member is allowed to crop is determined by his fair share of the biomass available for cropping. A legal basis for enforcing these regulations can easily be achieved through rules promulgated by the local government, or by the cooperative's established rules/regulations. Peer pressure among the members can also be a strong factor. Management of the co-operative is done by selected members. A portion of the members' earnings is channelled back to the co-operative for management support. Technical assistance should be extended to the cooperative by the government agencies concerned.

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SEMINAR PAPERS: SESSION IV
MANAGEMENT OF NATURAL RESOURCES OF AGAROPHYTES

GRACILARIA RESOURCES OF INDIA WITH PARTICULAR REFERENCE TO THE BAY OF BENGAL

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ABSTRACT

Thirty one species of Gracilaria are found on the Indian coastline of the Bay of Bengal. The estimated biomass of Gracilaria from Indian waters is 1700 tonnes. Studies on the cultivation and harvesting of Gracilaria *edulis* have shown that an interval of about six months between harvests will ensure continued good growth of the crop.

*   *   *

The genus Gracilaria is represented by 32 species in the Indian region. of which 31 are found in different parts of the Bay of Bengal coast. In respect of species diversity and biomass, *Gruciluriu* is second only to Surgussum of the Phaeophyta. Another noteworthy feature of *Gruciluriu* is the diversity of the species on the Indian coast which is not matched anywhere else in the world. It may, therefore, be stated without hesitation that Gracilaria is the most economically important genus on the Indian (Bay of Bengal) coast.

Two species of *Gruciluriu, G. corticuta* and *G.* folifera. are found more or less throughout the Indian coasts wherever the shore is rocky. On the other hand, a few economically important species like *G. edulis, G.* verrucosa, *G. fergusonii, G. bursa-pastoris* and *G. textorii* have restricted distribution. G. *eucheumoides* is found only in the Nicobar group of Islands in the Bay of Bengal.

Estimates of *Gruciluriu* resources on the Indian coasts have been made by several scientists using diverse methods. Table 1 summarizes the results of various estimates of India's Gracilaria resources based on the standing crop at the particular time.

Table 1: Estimates of available *Gracilaria* biomass from Indian waters

Author & year of publication	Locality & Area	Estimated bio-mass in tonnes
Varma & Krishna Rao 1962	Gulf of Mannar 235.25 sq. km	195.30
Krishnamurthy 1969	Drift on the Indian coasts	50.00
Umamaheswara Rao 1968	Pamban 3.58 sq.km	233.15
CSMCRI, Bhavnagar 1978	Tamil Nadu coast 1971-1976	1700.00

Earlier estimates by Koshy & John (1948), Chacko & Malu Pillai (1958), Thivy (1960) and Desai (1967) gave no details of the methods of survey, and were restricted to small stretches of the coast. Varma and Krishna Rao (1962) and Umamaheswara Rao (1968) described the methods they used, although their surveys were confined to small areas in the Gulf of Mannar and Palk Bay sides of Mandapam. Harvest figures, based on landings for Pamban, Periapatnam and Kilakkarai during 1966 to 1968, were given by Umamaheswara Rao (1968).

A study of seaweed drift on the Indian coast was reported by Krishnamurthy *et al* (1967) and by Krishnamurthy (1969). These drifts are particularly heavy in some parts of the Indian coast and may be used locally for manure and for bio-gas production. This survey indicated potential areas for more intensive surveys.

The more scientific and, therefore, more reliable survey made by a team of scientists from the Central Salt and Marine Chemicals Research Institute, Bhavnagar, in collaboration with other institutions like the Central Marine Fisheries Research Institute and the Departments of Fisheries of various State Governments, gave data that can be taken as the basis of future estimates. The survey, begun on the Tamil Nadu coast, was followed by a similar survey on the coast of Andhra Pradesh.

The *Gracilaria* resources of Tamil Nadu and Andhra Pradesh coasts of the Bay of Bengal are shown in Table 2. A perusal of this table shows that the total *Gracilaria* resources of the east coast of India assessed so far can sustain a production of about 75 tonnes of agar per annum, assuming that all of the *Gracilaria* can be harvested and utilized. In practice, however, it is neither feasible nor desirable to harvest the entire quantity available. Assuming that 50% of the standing crop can be harvested, it follows that only about 37.5 tonnes of agar can be produced. This is totally inadequate and will not meet Indian demand for agar.

Table 2: Estimates of available biomass of different species of **Gracilaria** from Tamil Nadu and Andhra Pradesh coasts (CSMCRI Surveys)

Species	Quantity in tonnes (Fresh weight)	Quantity in tonnes (Dry weight)
G. edulis	617.46	104.97
G. corticata	284.61	45.54
G. folifera	11.35	1.99
G. textorii	4.80	0.72
G. debilis	1.35	0.11
G. fergusonii	100.40	16.06
G. crassa	1.42	0.12
G. bursa-pastoris (G. compressa)	1.45	0.15
G. verrucosa	412.76	61.91
Other species (23)	474.16	71.12
Total of all species	1909.76	302.69

The agarophyte resources of India have been over-exploited and the biomass of these algae has been diminishing over the years. The estimates considered above are 15 to 20 years old and may not have much significance now. A renewed estimate, adopting a scientific method of survey and annual monitoring of the resources using remote sensing techniques, is essential to keep a watch over these resources.

Experimental work on repeated harvesting of a standing crop of *Gelidiella* ***acerosa*** (Joshi & Chauhan, 1985) has shown that adopting a sensible harvesting programme can ensure regrowth of the standing crop. Similar studies on ***Grucilaria*** would throw light on methods for conserving these resources. Studies on the repeated harvesting of cultivated ***Grucilaria edulis*** have shown that an interval of about six months between harvests will ensure continued good growth of the crop.

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GRACILARIA SPP. RESOURCES IN INDONESIA

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ABSTRACT

Commercial seaweed farming began in Indonesia on a small-scale in 1979. The three main species of ***Gracilaria*** in Indonesia are ***G. lichenoides,*** G. ***gigas,*** and ***G. verrucosa.*** This paper presents a study of the quality of ***Gracilaria*** collected from 31 locations.

Introduction

Indonesia's seaweeds of commercial importance are the agarophytes ***Gracilaria spp., Gelidium spp., Gelidiella spp.*** and ***Pterocladia spp.,*** and the carrageenophytes ***Eucheuma spp.*** and ***Hypnea spp.*** Until 1983, almost all of the seaweed products manufactured in Indonesia were derived from the harvesting of wild seaweed stocks. These are neither adequate in volume and reliability, nor competitive in cost. There are also problems with continuity of supply and in controlling the quality and quantity of the products.

Commercial seaweed farming began in Indonesia on a small scale in 1979, using ***Eucheuma*** spinosum. After more intensive study and development, further ***E. spinosum*** farming started in 1983. Farming of ***E. cottonii (E. averizii)*** began in 1984, in cooperation with the Genu-Kopenhagen pectin factory.

Indonesian agarophytes

An intensive study of Indonesian agarophytes was started in 1985. It involved collecting local species and analysing their quality; studying biological and environmental aspects in support of farming experiments; studying farming techniques and methods for experimental farm and farming development; and studying agar processing methods and the development of an agar processing industry.

Variation in the quality of some Indonesian Gracilaria

Indonesia's ***Gracilaria*** comprise three main species, namely ***G. lichenoides,*** G. gigas and G. ***verrucosa.*** The properties of seaweed samples collected during the period 1985-87 are given in the following table.

Variation in the quality of some Indonesian *Gracilaria* collected between 1985 and 1987

Location	Yield %	Gel Strength (g/cm)	Gelling point/ Melting point	Dried Product	Harvest Season
Terora, Bali	8.7	170	25/69	8.0	AG-JA
Geger , Bali	9.4	210	29/76	9.5	AG-JA
Paciran (1) East Jawa	18.7	880	41/88	80.0	(FA)
Paciran (2) East Jawa	17.9	960	41/90	140.0	(FA)

Location	Yield %	Gel Strength (g/cm)	Gelling point/ Melting point (C)	Dried Product (Ton/Yr)	Harvest Season
Sekotong (I) Lombok	19.2	890	40/92	60.0	JL-FB
Sekotong (2) Lombok	19.1	905	42/91	50.0	JL-FB
Lembar Lombok	17.3	825	39/90	SO.0	JL-FB
Lbhn. Haji Lombok	15.4	770	36/87	40.0	SP-FB
Tg. Gontor Sumbawa	16.9	900	39/91	60.0	SP-MR
Lbhn. Lalar Sumbawa	18.2	920	41/90	120.0	SP-FB
Sumbawa Besar, Sumbawa	16.6	740	35/87	40.0	JN-FB
Teluk Saleh Sumbawa	18.4	690	34/87	60.0	JN-FB
Dompu Sumbawa	20.6	720	36/88	50.0	SP-JN
Plbn. Ratu West Jawa	16.9	570	36/88	30.0	JL-DC
Lbhn. Banten West Jawa	17.1	710	34/83	35.0	AG-DC
Malimping West Jawa	16.7	770	41/87	40.0	AG-DC
Pameungpeuk West Jawa	15.4	480	33/81	35.0	OC-MR
Pantai Baron Jogyakarta	14.9	390	32/81	25 .0	NP-AP
Pacitan East Jawa	15.8	440	33/83	15.0	JN-DC
Warambadi Sumba NTT	18.2	660	37/87	25.0	AP --NR
P. Sawu(1) NTT	14.7	520	34/82	20.0	JL-JA
P. Sawu (2) NTT	17.1	690	35/89	45.0	JL-JA
P. Besar Flores	12.3	310	31/82	15.0	SP-JA
Tongga P. Rote NTT	17.4	720	36/89	40.0	JL-JA
Tg. Pila P. Rote NTT	13.3	290	32/86	10.0	AG-JA
Tg. Bunga South Sulawesi	18.1	710	39/89	35.0	(FA & WS)
Sibatua South Sulawesi	17.3	810	40/91	200.0	(FA)
Maros South Sulawesi	14.4	510	35/87	20.0	JL-DC

Location	Yield %	Gel Strength (g/cm)	Gelling point/ Melting point (C)	Dried Product (Ton/Yr)	Harvest Season
Mamuju South Sulawesi	17.5	965	41/92	-	(FA)
Takalar South Sulawesi	18.7	1090	40/92	60.0	(FA & WS)
Bone South Sulawesi	17.1	790	40/88	50.0	(FA & WS)

Notes: Moisture content of all samples less than 20%

- FA = Farming Area
- WS = Wild stock
- JA = January; FB = February; MR = March; AP = April; MY = May; JN = June; JL = July; AG = August; SP = September; OC = October; NR= November; DC = December

* = Estimated

SEMINAR PAPERS: SESSION IV
MANAGEMENT OF NATURAL RESOURCES OF AGAROPHYTES

AN INVESTIGATION OF SOME ENDEMIC AGAROPHYTES IN SOUTHWESTERN THAILAND

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ABSTRACT

Distribution of ***Polycavernosa*** along the coastline of Satul, Trang and Krabi Provinces was investigated. In Krabi Province, the highest occurrences were observed in June and the lowest occurrences in April. In Satul and Trang provinces, the highest occurrences were observed during January-April and the lowest occurrences during August-September. ***Gracilaria*** was found attached to the polyethylene net of fish cages, bottom sand, mud and underwater materials.

Conditions suitable for optimum growth of Polycavernosa were found to be : 29-32° C water temperature. 25-30 ppt salinity and 25-27 cm water depth.

Introduction

Gracilaria are used in the manufacture of various products which include human food, animal fodder, fertilizers and soil conditioners, and as raw materials for the chemical and pharmaceutical industries. The latter two are significant because they have a market worth of over US $300 million annually (HAI., 1986). Thailand exports seaweed (mostly ***Gradaria)*** totalling between 20 and 200 tonnes/year (dry weight), and valued at 4-10 million baht (HAI.. 1986)

At present, eight endemic agarophytes are found in Thailand (Abbott, 1987), four species belonging to the genus ***Gracilaria (C. tenuistipitata*** var liui, ***G. firma, C.*** irregularis and ***C.*** salicornia and four to the genus ***Polycavernosa (P.*** fisheri, ***P. changii, P. fastigiata*** and ***P.*** percurrrens). The major producing areas are the southern region of Songkhla lake and the shallow mudflats in Pattani Bay (Tachanoravong. 1989).

The purpose of this study was to investigate the natural growth of endemic agarophytes in southwestern Thailand (Krabi, Trang and Satul provinces). The results can be used as basic information for natural production management and for future studies of culture techniques.

Method

The investigation was conducted between November 1987 and April 1988 in the coastal areas of Krabi, Trang and Satul provinces. A pre-survey in the three provinces was done in November 1987, in order to study basic information on natural production of ***Gracifaria*** and ***Polycavernosa.***

The investigation was carried out at 11 stations in Krabi province. six stations in Trang province and 10 stations in Satul province. Every survey station was investigated twice during the period of study.

Water and air temperatures were recorded by mercury thermometer, and water salinity was measured by hand refractometer.

The natural growth of seaweed which attached to fin-fish net cages was recorded. The growth period and seasonal fluctuations were observed. The total amount of endemic agarophytes in the fin-fish net cages was weighed. An estimate of production for the harvesting season was made as follows:

1. The cages with attached Polycavernosa were taken out and weighed by direct balance (wet weight). (The size of fin-fish net cages is around 5 x 5 m and 2 m in depth).
2. The frequency of cleaning the net cages was recorded. The weight of Polycavernosa removed when cleaning the net cages each time was estimated and recorded.
3. Total amount of Polycavernosa which could possibly be harvested in a year was estimated.

Results

During this investigation, only the genus ***Polycuvernosu*** spp. was found. No members of the genus Gracilaria ***were*** found during this period. The species of Polycavernosa ***spp.*** may be ***P.*** changii (Abbott, 1987), but a further study on species classification is recommended. ***Polycuvernosu*** were found on the polyethylene net of fish cages at a depth of 40-70 cm from the water surface.

At the 11 stations surveyed in Krabi province, ***Polycuvernosu*** was found mostly in March, May, June and July. At some stations, ***Polycuvernosu*** were found all the year round. Total amounts of Polycuvernosa found ranged from 20-50 kg/cage per season. It is estimated that a total amount of 22,130 kg may be available for harvesting each year (Table 1). Fish culturists in Krabi province harvest only a few kilograms of Polycuvernasa for selling fresh in the local market.

Table 1: Natural growth of Polycuvernosa sp. on finfish net cages in Krabi province.

St	Period (month)	Salinity (ppt)	***Temp C*** W.	A.	***No.*** cages	Weight kg/cages	Total Wt. kg.
1	7- 12	30	32	38	52	50	2600
2	5- 6	30	32	33	26	35	910
3	s - 6	30	30	32	100	35	3500
4	6	31	29	31	48	35	1680
5	1 -12	30	31	32	16	35	560
6	1 - 12	25	32	38	20	20	400
7	1-12	29	32	34	8	20	160
8	3	24	29	29	70	20	1400
9	1- 12	25	30	31	120	50	6000
10	1-12	25	29	30	140	35	4900
11	I - 12	28	29	32	-	20	20
Total	-	-	-	-	338	355	22130

At the six stations surveyed in Trang province, Polycarvernosa was found mostly in January, February. March and April, although at some stations it was found all the year round. Total amounts of Polycavernosa ranged from 20-35 kg/cage per season. An estimated total of 5,075 kg may be available for harvesting each year (Table 2). There is no local market for ***Polycuvernosu*** in Trang province.

Table 2: Natural growth of Polycavernosa sp. on finfish net cages in Trang province

St	Period (month)	Salinity (ppt)	***Temp C.*** W.	A.	***No.*** cages	Weight kg/cages	Total Wt kg
1	3-- 4	28	29	30	-	20*	20
2	1	27	29	31	16	35	560
3	1 - 12	27	32	33	12	20	240
3	1-12	25	31	30		20”	20
5	1- 12	25	31	30	210	20	4200
6	2	25	31	30	-	35	35
Total	-	-	-	-	238	150	5075

* No finfish net cages, it can be found attached to underwater stone, sand and mud.

At the 10 stations surveyed in Satul province, Polycavernosa was found mostly in March and April. Again, as in Krahi and Trang. it was found at some stations all the year round. Total amounts of Polycavernosa ranged from 20-50 kg/cage per season. An estimated total of 26.545 kg may be available for harvesting each year (Table 3).

Table 3: Natural growth of polycavernosa **sp. on finfish net cages in Satul province**

St	Period (month)	Salinity (ppt)	Temp C W.	Temp C A.	No. Cages	Weight kg/cages	Total Wt. kg.
1	3 - 4	30	30	34	-	35*	35
2	4	32	31	32	88	35	3080
3	4	35	29	30	-	20	20
4	4	30	29	34	60	50	3000
5	4	31	30	34	120	20	2400
6	3- 4	28	30	31	70	20	1400
7	1 - 12	25	29	33	70	20	1400
8	3- 4	23	36	38	310	35	10850
9	12- 4	25	34	35	180	20	3600
10	12- 4	22	34	36	38	20	760
Total	-	-	-	-	936	275	26545

* No fin-fish net cages, it can be found attached to underwater stone, sand and mud.

There is no local utilization of Polycavernosa. A few fish culturists in Satul province have been informed about the market potential for this seaweed, but no local market has developed up to the present time.

The physico-chemical properties of the coastal water in fin-fish net cages in southwestern Thailand were investigated the previous year (Tookwinas et al., 1985). Water visibility ranged from 0.39-1 .57 cms. Other water properties are shown in Table 4.

Table 4: Average physico-chemical properties of coastal water in finfish net cage and coastal aquaculture ground area in Southwestern Thailand (Tookwinas el al. 1985)

St	Depth m	Visibility m	D.O. mg/L	pH	Salinity %	NH-N mg/L	NO-N mg/L	PO mg/L	Si mg/L
1	1.72	1.03	5.60	8.10	30.10	0.00096	0.00294	0.0290	2.77
2	1.32	0.75	6.30	8.10	29.70	0.0016	0.0030	0.0180	2.80
3	5.44	1.43	4.60	7.80	28.90	0.0034	0.0026	0.0045	2.49
4	3.16	1.57	5.32	7.80	30.23	0.0110	0.0026	0.0590	2.02
5	0.88	0.61	5.24	7.99	29.40	0.0032	0.0020	0.0200	3.10
6	1.22	0.74	4.56	7.79	24.06	0.0028	0.0023	0.0172	2.35
7	0.90	0.47	5.53	7.69	24.79	0.0130	0.0004	0.0460	2.46
8	1.26	0.66	4.71	7.58	20.50	0.0180	0.0055	0.0490	2.74
9	1.55	0.80	4.85	7.62	17.19	0.0210	0.0170	0.0250	2.53
10	2.62	0.98	4.88	7.72	25.51	0.0128	0.0028	0.0570	2.505
11	4.20	1.34	4.45	7.51	25.90	0.0146	0.0016	0.0550	2.73
12	1.72	1.06	5.03	7.56	24.06	0.0200	0.0025	0.0703	2.60
13	1.54	0.80	5.21	7.73	28.73	0.0120	0.0030	0.0580	2.78
14	1.04	0.52	5.88	7.90	29.65	0.0380	0.0056	0.0300	1.96
15	1.62	0.75	5.94	8.01	30.05	0.0160	0.0035	0.0440	2.27
16	4.96	1.08	5.19	7.94	25.22	0.0200	0.0025	0.0430	2.10
17	2.53	1.00	5.09	7.77	17.83	0.0120	0.0022	0.0460	2.51
18	1.00	0.47	5.66	7.73	26.75	0.0098	0.0035	0.0540	2.72
19	1.26	0.39	5.57	7.87	27.36	0.0320	0.0088	0.0630	2.43

Conclusions and Recommendations

There is a potential Polycavernosa production of approximately 53.7 tonnes (wet weight) in the three provinces. This is equivalent to a dry weight of about 7.7 tonnes.

At present, there are no agar processing plants in Thailand. Thailand exports dry seaweed to Japan, West Germany, Hongkong and Malaysia at quantities ranging between 20 and 200 tonnes/year. Agar is imported at quantities ranging between 200 and 300 tonnes/year, at a value of 50 to 100 million baht. Some of the seaweed production is utilized and consumed in Thailand, but the bulk is exported (HAI, 1986).

The export of dry seaweed fluctuates. This may be due to the poor quality of the local product, and irregular supply. These factors discourage fish culturists from cultivating endemic agarophytes in Thailand.

Information from this investigation indicated that the selling price for dry *Polycavernosa* is very low. Fish culturists in Krabi province were informed that dry *Polycavernosa* could be sold for 15 bahtkg, compared to around 2 baht/kg for the fresh product. This price would not provide an incentive for fish culturists in the area to farm *Polycavernosa*. It seems likely that a selling price of more than 30 baht/kg for dry *Pofycavernosa* would be required to stimulate interest in *Poly-cavernosa* farming.

There have been initial experiments in culturing *Gracilaria* and *Polycavernosa*. One of these experiments used polyculture in fin-fish net cages. These seaweeds can grow on the polyethylene net and on the bottom of the cages. Production levels ranged between 50 and 100 kg/100m2 /year (Tachanaravong, 1989). Fish culturists would harvest by cutting, leaving around 5 to 10 cm of *Gracilaria* and *Polycavernosa* shoot. The shoots re-grow to harvesting size in 2-3 months. This method could be adopted by fish culturists in southwestern Thailand, which is the largest area for brackishwater fish cage culture in the country. There appears to be potential for producing large quantities of seaweed in this way.

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