

Bay of Bengal Programme

Small-Scale Fisherfolk Communities

SEAWEED (*GRACILARIA EDULIS*) FARMING

IN VEDALAI AND CHINNAPALAM, INDIA

BOBP/WP/65



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Small-Scale Fisherfolk Communities

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**Seaweed (*Gracilaria Edulis*) Farming
in Vedalai and Chinnapalam, India.**

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This paper describes some trials with seaweed (*Gracilaria edulis*) farming in the open sea. These trials were carried out between 1987 and 1990 in Vedalai and Chinnapalarn, two coastal villages in Ramanathapuram district, Tamil Nadu, India. The purpose of the trials was to discover whether the collectors of wild seaweed in the area could augment their income by cultivating seaweed and, thereby, also possibly preserve their natural resource, which is believed to be diminishing through over-exploitation.

The trials were undertaken by the villagers themselves, with support from the Bay of Bengal Programme (BOBP) and the Tamil Nadu Department of Fisheries.

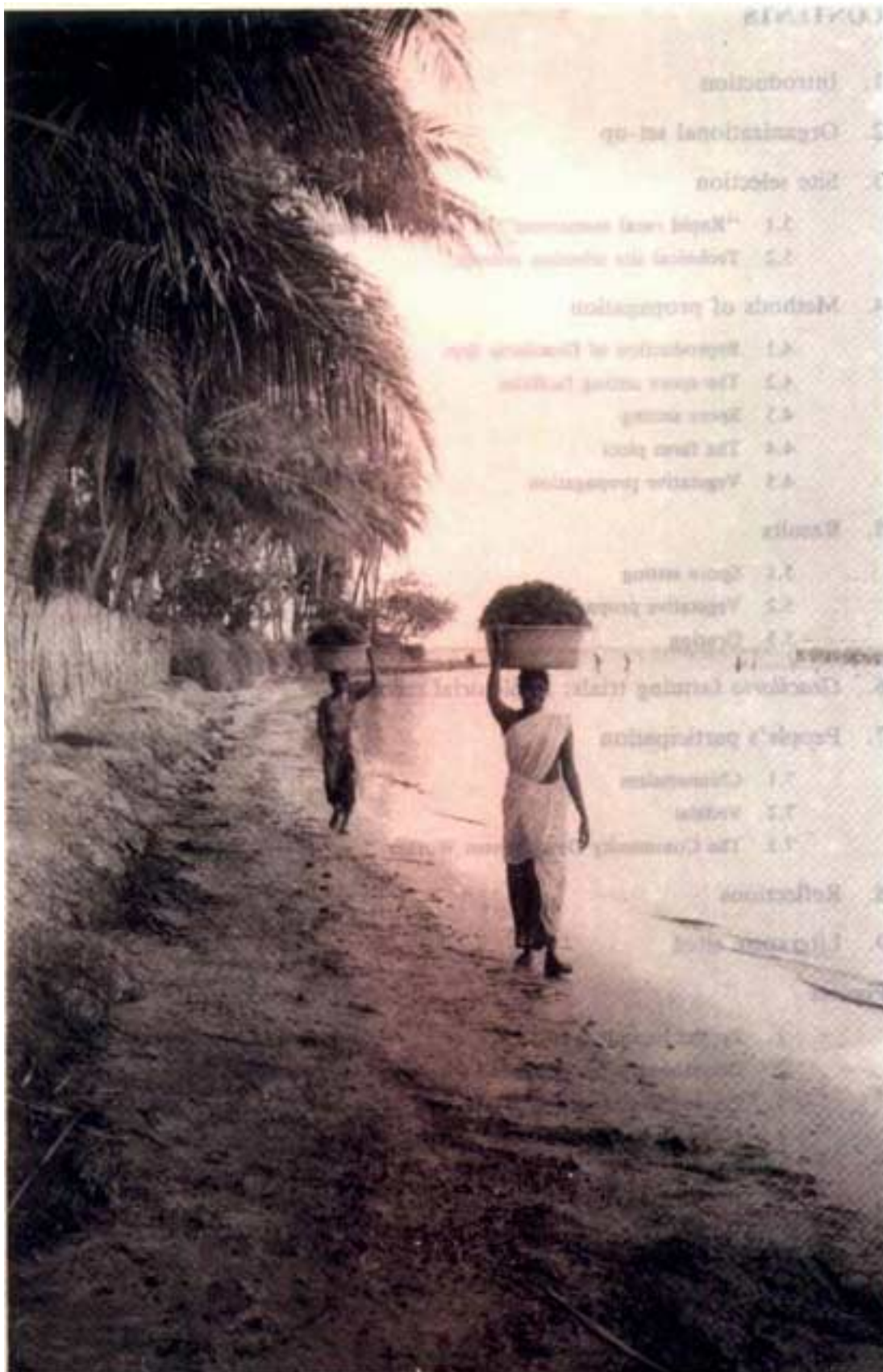
The seaweed farming project, and this paper which reports on it, have been sponsored by BOBP's "Small-Scale Fisherfolk Communities in the Bay of Bengal" (GCP/RAS/118/MUL), a project jointly funded by SIDA (Swedish International Development Authority) and DANIDA (Danish International Development Agency) and executed by FAQ (Food and Agriculture Organization of the United Nations). Parallel with the culture trials, attempts were made to introduce simple agar processing technology at village level and this is described elsewhere. That work was carried out but the Post-Harvest Fisheries project of BOBP which is funded and executed by the ODA (Overseas Development Administration) of the United Kingdom.

The BOBP is a multi-agency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. The Programme plays a catalytic and consultative role: it develops, demonstrates and promotes new techniques, technologies or ideas to help improve the conditions of small-scale fisherfolk communities in member-countries.

This document is a working paper and has not been cleared by the governments concerned or the FAO.

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The seaweed harvest is carried to the village from one of the BOBP-assisted farms in Ramanathapuram District, Tamil Nadu, South India.

1. INTRODUCTION

Gracilaria, an agar yielding red seaweed, is geographically distributed between 50° North latitude and 50° South latitude. It is collected from its natural grounds or from waters where it is cultivated and then processed into food, bacteriological or industrial agar. The biggest producer of *Gracilaria* is Chile, followed by the Philippines and South Africa. Japan is the largest producer of agar as well as its largest consumer; in 1984, its production was 2,440 tonnes (Coppens, 1990).

Because of the increasing demand for agarophytes, cultivation of *Gracilaria* has become more important during the last few years. It is being successfully cultivated in ponds in China, Taiwan and, more recently, Indonesia. But *Gracilaria* culture in tropical, open water systems is still experimental. However, positive results have been reported from the West Indies. Smith *et al.* (1984) successfully cultured *G. domingensis* both vegetatively and through spores set on lines placed in natural seaweed beds.

BOBP's first attempt at experimental farming of *Gracilaria* in the open sea was in Penang, Malaysia in 1983-84 (Doty and Fisher, 1987). Spore setting was employed to propagate *Gracilaria edulis* by seeding raffia lines, which were then outplanted in experimental plots on a shallow bank in Penang Strait. The best production was over 1 kg wet weight per metre. Although initial results were promising, the culture work was never taken up on a commercial scale.

The Central Marine Fisheries Research Institute (CMFRI) and the Central Salt and Marine Chemicals Research Institute (CSMCRI) of India had in the past undertaken various studies and culture trials of *G. edulis* and other agarophyte species found in the Mandapam area of southern Tamil Nadu, India (Krishnamurthy *et al.*, 1978; Rao, 1974). Both floating and bottom culture were tried on a small scale. The short-term trials seemed to indicate that *Gracilaria* farming would be feasible. There is also information available on the patterns of spore release for several *Gracilaria* sp. found in the Mandapam area (Chennubhotla *et al.*, 1986). The Tamil Nadu Fisheries Department had also conducted trials on the seaward side of Kurusadai Island. Vegetative propagation had been used and there appeared to be very little grazing (Paramasivam, personal communication).

Encouraged by the trials in Malaysia and the experiments by the Central Marine Fisheries Research Institute in India, BOBP decided to support another *Gracilaria* farming project in Ramanathapuram (Ramnad) District in Tamil Nadu.

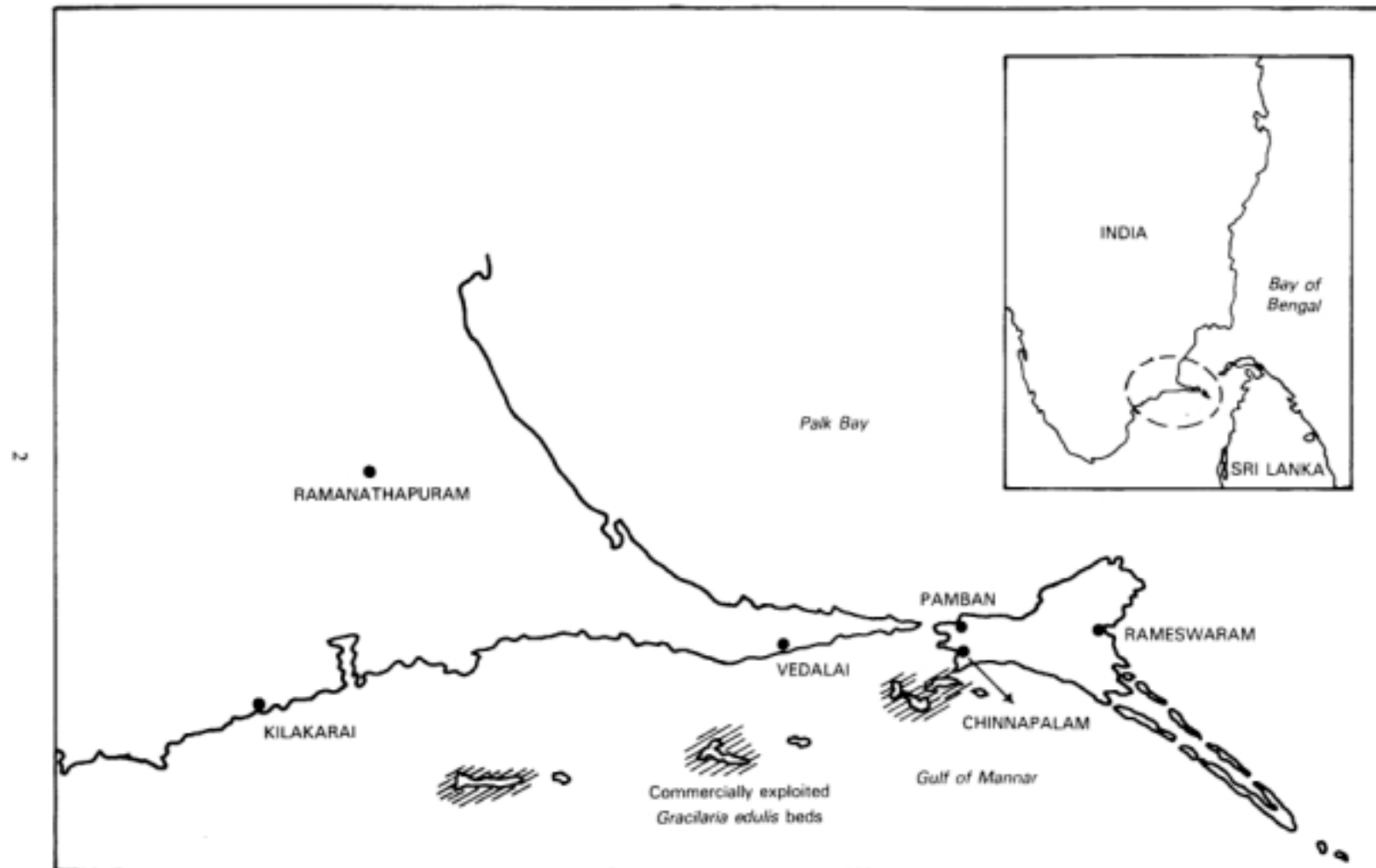
BOBP undertook a two-month field study in the Mandapam area in 1986 to assess the present situation of the industry (Usitalo, 1986). In many of the coastal villages of Ramnad District, seaweed collection is an important source of income. Men and women go out to the offshore islands, almost throughout the year, to collect seaweed. Species being collected are *Gracilaria* and *Gelidiella*, for agar production, and *Sargassum* and *Turbinaria* for alginate production. Seaweed is sold to agents, who in turn sell it to processing factories.

There were several reasons for BOBP to support an experimental *Gracilaria* farming project in Ramnad District. In the first place, there is some concern that the seaweed resource, especially agarophytes, is diminishing through over-exploitation. While there have been no recent resource assessments, seaweed collectors complain of declining harvests (Usitalo, 1986). Although no exact data are available, it is clear that the demand for agarophytes is increasing and exceeds supply. Secondly, there is the establishment of a marine national park by the Government of Tamil Nadu. The park includes the seaweed islands in the Gulf of Mannar. This may deny collectors access to these traditional seaweed grounds, cutting off an important source of supply and adversely affecting their incomes. Alternative opportunities are limited, as the region is semi-arid and agriculture poorly developed.

It was anticipated that seaweed farming would help the collector to get over the problems he is facing with the resource. It was also felt that such farming would require little capital investment. In 1987, the project started with an expected duration of 4-5 years. Its main objectives were:

- To assess the technical, economic and social viability of seaweed culture in the Ramnad area;
- To introduce commercially oriented practices suitable to the environment and social conditions;

Fig. 1. Project location map



- To increase the level of training in seaweed culture once trials become successful; and
- To conduct marketing trials in order to find a way to make the farmers less dependent on agents.

2. **ORGANIZATIONAL SET-UP**

Three parties were involved in the trials : The Government of Tamil Nadu Fisheries Department, BOBP and the villages. A research assistant from the Fisheries Department was appointed to work full time with the seaweed project and help the village people implement culture trials. The BOBP gave technical support and monitored the project. Materials to construct spore-setting facilities and pilot farm modules were supplied, as well as laboratory and field equipment for biological monitoring. A community development worker from BOBP helped to motivate and organize the village people.

The villages of Vedalai and Chinnapalam were selected in early 1987 after a survey of 15 coastal villages in the seaweed production area (Fig.1). The survey was conducted by two socio-anthropologists and a national consultant, aided by the Tamil Nadu Fisheries Department. Vedalai and Chinnapalam were selected to conduct seaweed culture trials for the following reasons:

- Seaweed collection is done almost throughout the year on a large scale in these villages;
- The two villages were willing to organize themselves and take responsibility for the day-to-day management of the project;
- The people here had already seen the seaweed culture work of several research institutes;
- Area for culture work was available; and
- There was an absence of shore seines and castnetting.

Committees were formed in both villages and, with 25 people in Vedalai and 20 in Chinnapalam, preparatory work began in April 1987. A total of 45 farm plots of 0.1 ha each were established and a spore setting shed with six tanks was constructed in Vedalai. Another spore setting shed was constructed in Chinnapalam in mid-1988.

At an early stage in the trials, it was apparent that value-added processing would be required to achieve an adequate return on investment. Therefore, as a parallel activity, BOBP's post-harvest fisheries project implemented agar production trials utilizing the simple technology described by Kalkman (1990).

3. **SITE SELECTION**

Conceptually, this pilot project was directed at BOBP's target group, the small-scale fisherfolk. Technical factors alone could not be the criteria for siting the project; social acceptability was equally important. Consequently, a research and planning exercise was undertaken to identify potential villages where seaweed trials could be technically and socially feasible. The people in each contact village were encouraged to consider carefully the proposed pilot project and, in the event they favoured it, to organize themselves to participate in the trials.

3.1 *“Rapid rural assessment” of target communities*

Three social scientists, two men and a woman, were trained in participatory research and planning and spent approximately one month in the field, having discussions with the communities of 15 villages in Ramanathapuram (Fig. 1). These villages were identified with the help of the Department of Fisheries and CMFRI as villages where seaweed collection was practised.

The exercise was undertaken in two stages of 15 days each. In the first stage, the researchers visited the villages and tried, with the help of the communities, to understand the socio-economics of the villages. During group discussions, the dynamics of the communities, in terms of their social, religious and economic stratifications, the practice of seaweed collection and marketing, the environmental viability of seaweed culture and space availability were discussed. The discussions brought out the interest of each community and its willingness to participate in the pilot project.

The seaweed resource situation was discussed with the communities in terms of seaweed scarcity due to overharvesting, restriction of collection zones by the Government of Tamil Nadu, and the use of potentially destructive harvesting methods. The process of seaweed culture was described and the social, resource allocation of common property, benefit sharing and organizational aspects were

discussed. Secondary data was collected, through the focus group discussions with various constituencies, discussions with village leaders and community meetings. Serious efforts were made to encourage the community to articulate and think through its problems and any that might arise through the proposed activity. No decisions or suggestions were made by the team on behalf of the community; at best, questions were raised. Particular emphasis was placed on the fact that the selected communities would be partners and not workers in the trials. They would have to take full responsibility for the local management of the activity. Inputs from BOBP would be restricted to some funds and technical components. The initial survey reduced the number of potential villages from 15 to five.

In the second stage, a more concentrated effort was made in the five short-listed villages to fill in the gaps of knowledge and to involve the communities in preliminary planning and organizing for the seaweed culture trials. Similar methods as used in stage one were employed. The second stage analysis further reduced the potential villages to two, Vedalai and Chinnapalam.

These two villages agreed to the culture trials and committed themselves, as communities, to the task by creating management committees, allocating water areas for culture, suggesting and selecting participants and proposing benefit-sharing procedures. The village leaders committed themselves in writing to their ideas and suggestions regarding the latter.

3.2 Technical site selection criteria

In the coastal area of Ramnad District, *Gracilaria* species grow near the offshore islands on a relatively sandy bottom 0.5-2 metres below the water surface. *Gracilaria* plants usually attach themselves to small shells or coral stones and, sometimes, to other species, like the seagrass *Thalassia*, found there.

To select a culture site close to the islands was not possible for two reasons. First, the islands are being considered as part of a proposed national park. And, secondly, the islands are more than an hour by boat from the villages, which makes it difficult to keep a close eye on the farms. Furthermore, during the monsoon periods, it is sometimes impossible to reach the islands because of rough seas. Selecting sites near shore areas close to Vedalai and Chinnapalam for the pilot farms seemed to be a reasonable idea, since the environmental circumstances (water depth, moderate wave action, substrate) were similar to those close to the islands. Farms would be easy to maintain and daily visits could be made.

4. METHODS OF PROPAGATION

4.1 Reproduction of *Gracilaria* Spp.

Gracilaria spp. belong to the phylum *Rhodophyta*, or red algae. The *Rhodophyta* are characterized by complex life cycles involving the alternation of sexual and asexual generations (Fritch, 1935). Figure 2 illustrates the life cycle of a typical *Gracilaria* sp.

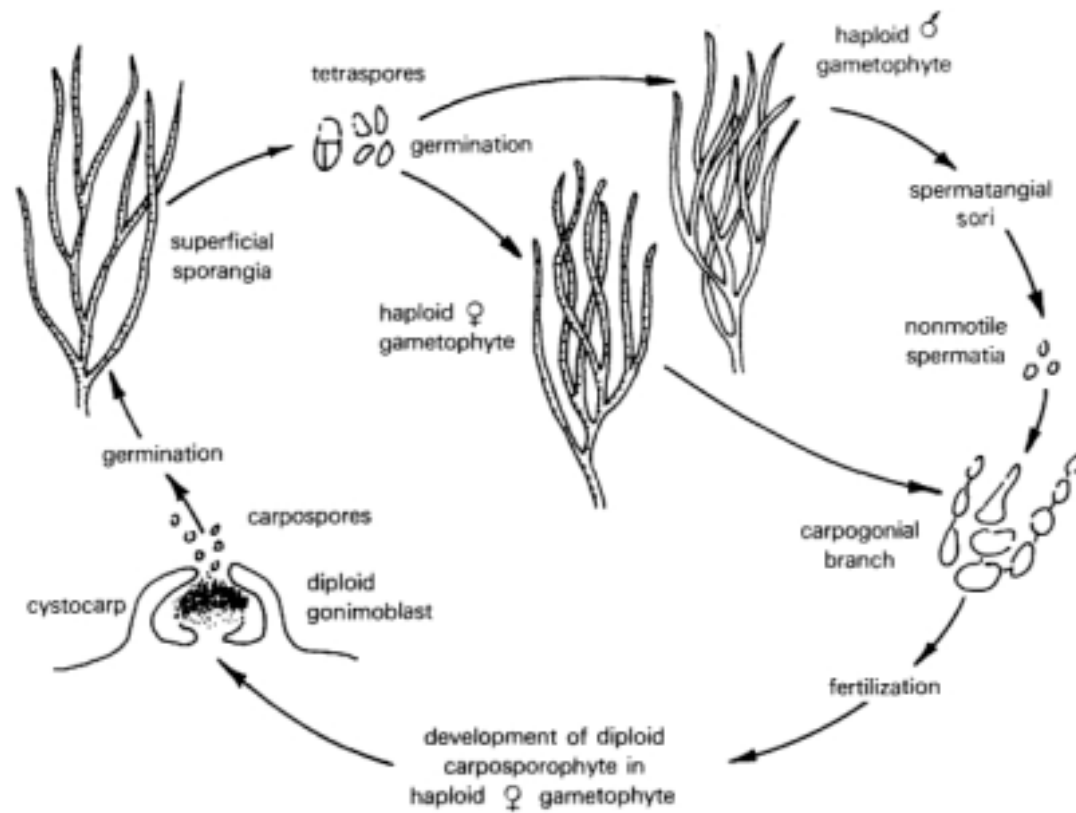
Natural propagation is through the release of spores, either asexual tetraspores or sexual carpospores. Tetraspores are haploid and give rise to the sexual generation in which male and female plants produce gametes in specialized structures termed sporangia. Fertilization occurs in the female plant within the carpogonium. This structure develops into the cystocarp from which the carpospores are released. The cystocarp is readily visible as a hemispherical nodule slightly less than 1 mm diameter on the surface of the thallus. Carpospores germinate into diploid plants which produce haploid tetraspores through meiosis. Tetraspores arise within the cortex of the thallus and are released through the plant wall. They are not contained within any specialized structures and are not visible to the naked eye, being only about 35-40 microns in diameter.

Gracilaria can be propagated by either type of spore, depending upon the relative abundance of one or the other generation. Female plants were rarely found in the Mandapam area, hence tetraspores were primarily utilized in the spore setting operation. Tetraspores had also been used in the Malaysian trials (Doty and Fisher, 1987) with good results.

An advantage of controlled spore setting is that, in the case of loss of the total harvest, a new start can be made easily.

The thallus of *Gracilaria* is unspecialized, so any piece taken from it can be vegetatively propagated. Such plants may mature and produce spores which could, theoretically, be used to seed farms. In the future, selection of strains may be possible through the application of spore setting technology.

Fig. 2 Diagrammatic life history of *Gracilaria*. (After Dawson 1966)



The first trials on spore setting in Vedalai were started early in 1988 and in Chinnapalam in August 1988.

4.2 *The spore setting facilities*

Two spore setting sheds were constructed during the course of the trials. The first was in Vedalai. The structure, housing six setting tanks, was fabricated of local thatch materials. The setting tanks were of plastic liners supported by palmyrah leaf stocks lined with aluminium sheet. A cement pad had to be constructed under the plastic tanks to prevent rodents from burrowing below the tanks and perforating the liners.

Water was supplied by a 37.5 mm portable pump whose intake was placed just below the water line. The nearshore water was too turbid to directly fill the setting tanks, so incoming raw sea water was gravity sand filtered.

For the second facility, at Chinnapalam, brick and cement tanks were used for water storage and setting tanks. The gravity sand filter was incorporated into a water storage tank of about 5 MT capacity. The housing was similar to that constructed at Vedalai. This set-up proved not only more economical than the one at Vedalai, but also more durable.

4.3 *Spore setting*

Seed stock material was collected from the natural seaweed grounds near the offshore islands. Cystocarpic (haploid female) and tetrasporic (diploid asexual) plants are usually used for reproduction, but as it is difficult in the field to distinguish male plants from tetrasporic plants and the cystocarpic plants were very few, both types of plants were used for spore setting. During transportation from the collecting grounds to the spore setting facilities, the seaweed was kept moist and as cool as possible. Before starting the spore setting, the seaweed was washed with sea water to remove other algae and sediment.

The material used for the spores to set on was a cheap, thin HDPE (high density polyethylene) string, locally known as “raffia” line. Other materials, such as coir rope, monofilament, HDPE rope and extruded HDPE, were also tested, but as there was no difference in the end results and raffia was the cheapest, it was used for most spore settings. PVC frames of 40 by 100 cm, wrapped with 100 m of raffia line, were placed at the bottom of a tank, in which the water depth was 40 cm. To allow the water to cool and the sediment to sink to the bottom, the tanks were filled one day before the spore setting operation took place.

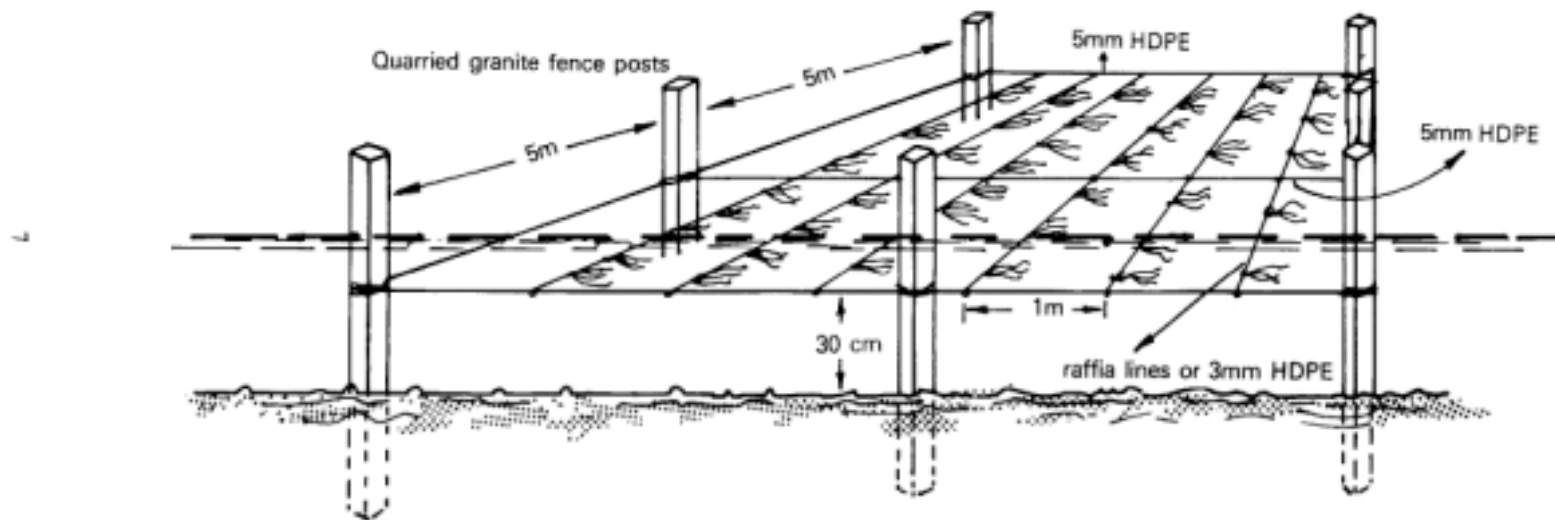
To support the seedstock, a net was placed about 30 cm above the frames. Big branches were broken into smaller ones and the seaweed was spread evenly over the net. The total amount of seedstock varied from 4 to 12 kg per tank (8 m² in Vedalai and 4 m² in Chinnapalam). During spore release, which occurred overnight, no water movement was permitted as this would have prevented the spores setting on the raffia lines. Microscope slides were placed under the seedstock to enable the spore release and the viability of the spores to be checked under the microscope. The spore setting was conducted over two nights. On the third day, the seedstock material was removed.

The seeded material was transferred to the farms after two, three or four nights. During outplanting, the seeded raffia lines were kept under water to prevent them from drying. The lines were placed at 20cm intervals, between stone posts, and kept clean from pest algae and sediment. It takes three to six weeks before *Gracilaria* outgrowth is visible and several months before the plants reach an appreciable length.

4.4 *The farm plots*

Each farm plot was set up to support 1000 m of raffia line and enclosed about 0.1 ha. The shape of the rectangular plots varied according to the bottom topography. Stone fence posts were inserted into the sandy bottom using a water pump to ‘jet’ them down to a depth of about 1 m. The operation was simple and fast, requiring only about a minute to set each post into position and insert it into the sea floor. The posts were heavy and difficult to handle, but alternatives were not available. Once set, granite posts have an indefinite lifespan. A few broke during handling, but the percentage was small. Most plots required 33 to 35 posts. A portion of a typical plot is sketched in Fig. 3.

Fig. 3 Portion of a farm plot



The raffia lines were tied at various heights above the sea floor, but always low enough to prevent exposure at low tide. The lines were supported every five metres by 5 mm HDPE lines running perpendicular to the raffia.

4.5 *Vegetative propagation*

Vegetative propagation was also tried.

Vegetative cuttings of *Gracilaria* plants, which were collected from the natural grounds, were inserted in 3 mm HDPE rope. Insertion was facilitated by the use of a “fid” made from a short length of 13 mm PVC pipe (Fig.4). After pushing the fid into the lay of the rope, a cutting, or bunch of cuttings, could easily be inserted into the resulting opening. The average weight of seed stock was estimated at .07 kg/metre of growout line.

Other material, like raffia line and coir rope, was tried, but, although a little more expensive, HDPE rope was the most suitable material. The ropes with vegetative cuttings were outplanted on the farms between the stone posts as described above. Grow-out lines were spaced at intervals varying between 0.5 and 0.2 m. Grow-out time was three months.

5. **RESULTS**

5.1 *Spore setting*

Germination of *Gracilaria* spores was very poor compared to the results of the Penang, Malaysia, project (Doty and Fisher 1987). Spore release was examined regularly under the microscope and, often, more than ten spores per 10 cm of raffia line were found. However, once the seeded lines were transplanted in the sea, only a few plants were found surviving one or two months later.

After almost a year of spore setting experiments and no positive results, they were abandoned in both villages. It is very difficult to say exactly why spore-setting failed, but it could be a combination of such factors as

- Non-availability of mature seedstock
- Handling of the seedstock and seeded lines
- Inadequate water quality compared to the seedstock’s native environment; and
- Grazers.

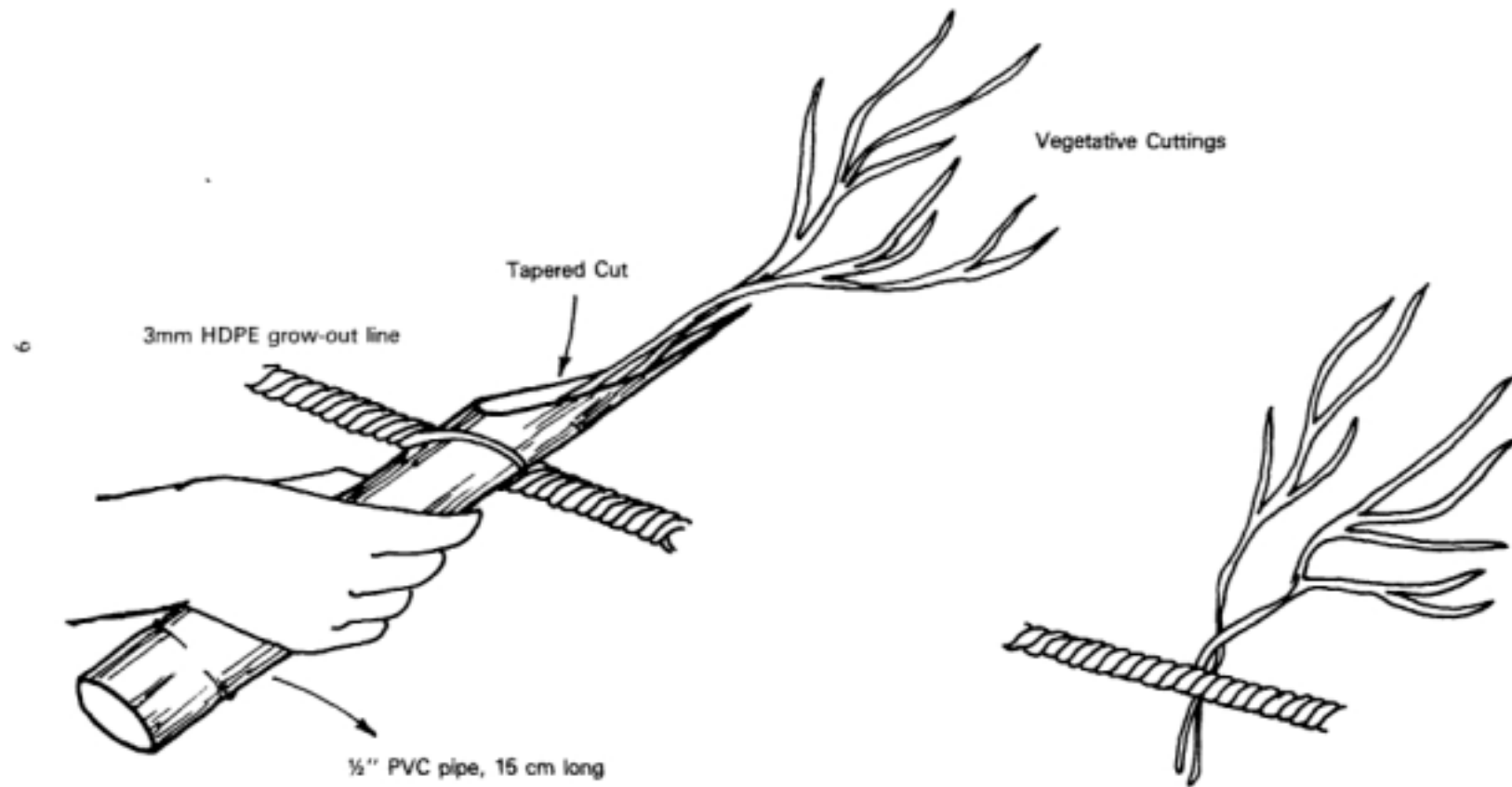
At a similar *Gracilaria* farming project in Sri Lanka, it was found that by using only female plants (carpospores) as seedstock material for spore setting, positive results were obtained during certain months of the year. In India, female plants were rarely encountered in the natural seaweed beds around the islands and, therefore, female, male and tetrasporic plants were used as seedstock material. In many cases, the seedstock may have also been immature, releasing few viable spores.

The treatment of the seedstock material while transporting it from the islands to the shore and subsequent cleaning procedures might have caused damage to the plants and spores. During transport, it was not always possible to keep the seaweed wet and cool. Washing was minimized in Sri Lanka to avoid stressing the plants and causing premature spore release. In both Vedalai and Chinnapalam, seaweed was repeatedly washed; plants and spores might have consequently been damaged and released before the actual spore setting took place.

Compared to the offshore islands, sedimentation and fouling were much more pronounced here. Water temperature and salinity did not fluctuate much throughout the year and varied between 28—32°C and 30—35 ppt respectively.

A deficit of the correct concentration of nutrients in the seawater might have caused poor development of the spores. Small unidentified gastropods were frequently observed on outplanted lines and could have grazed on the few plants which germinated. The alternative of keeping the seeded lines in the tanks for a few more weeks was not feasible because of lack of space, light and other facilities.

Fig. 4 Fid used to insert vegetative cuttings into grow-out line



Little is known of the germination of spores of the Mandapam species of *Gracilaria*. Although it may follow the generalized life cycle as given by Dawson (1966), environmental changes can influence germination and morphology of the thallus (Plastino and de Oliveira, 1988). Stress, induced by unknown differences in water parameters between the offshore islands and the near-shore culture site, could have induced such changes leading to the failure of germination.

Causey *et al* reported that *G. converfoides* in North Carolina, USA, entered a six-month dormant period soon after both carpospores and tetraspores germinated and developed a primary protonema. However, we did not observe any significant germination one year after outplanting seeded lines.

5.2 Vegetative propagation

Trials with vegetative propagation started at the end of 1988. The results of five trials are shown in the table below.

**Table 1 : Production results from five culture trials
at Vedalai and Chinnapalam**

| <i>Trial No.</i> | <i>Harvest Time</i> | <i>Village</i> | <i>Lines Harvested (m)</i> | <i>Wet Weight Harvested (kg)</i> | <i>Productiwtg kg/rn</i> |
|------------------|---------------------|--------------------|----------------------------|----------------------------------|--------------------------|
| | Feb 89 | Vedalai | 42,000 | 761 | .02 |
| 2 | Nov 89 | Vedalai | 890 | 152 | .17 |
| 3 | Nov 89 | Vedalai | 110 | 49 | .45 |
| 4 | Nov 89 | Vedalai | 920 | 149 | .16 |
| 5 | Feb 89 | Chinnapalam | 8,000 | 58 | .01 |

Chinnapalam produced only one harvest with a very low yield. Production at Vedalai showed some improvement in the latter half of 1989, but poor regrowth immediately after harvesting led to termination of the project. Regrowth of the cuttings after the first harvest in February 1989 was good until April, when rabbit fish (*Siganus spp.*) appeared. Their effect was devastating and the 4.5 ha farm was completely wiped out. However, the trials were continued in a smaller area (one plot of 0.1 ha in each village) to determine whether the appearance of rabbit fish was seasonal.

Besides grazing, there were other problems. A filamentous green algae (*Chaetomorpha spp.*) was seasonally abundant, particularly in Chinnapalam. Large quantities often became entangled with the *Gracilaria* causing shading which retarded growth and resulted in death of some of the plants. Extreme low tides left some seaweed lines exposed to the sun, with consequent drying out. Some of the cuttings also started to decay and dropped off the ropes. These problems were minor compared to the grazing problem and, therefore, several methods were tried to protect the seaweed from rabbit fish (see 5.3).

Initially, vegetative propagation used bunches of cuttings inserted into the line. It was hypothesized that shading could cause growth retardation or even decay of thalli in the centre of the bunch. For what turned out to be the final trial in the last quarter of 1989, only a few cuttings were inserted at each point.

Trial 3 was in a very small plot adjacent to the 0.1 ha fenced module at Vedalai. This plot was fenced and only about 110 m of seeded line was placed on the sea grass-covered bottom. Harvesting began in mid-November. Care was exercised while pruning the plants to leave sufficient biomass for rapid re-growth. Although the past experience had shown the last and first quarters of the year to be the best for growth, all the pruned thalli degenerated and eventually died shortly after harvesting. At this point the project was terminated.

5.3 Grazing

Four methods of protecting the seaweed from rabbit fish were tested in both villages:

- Scare lines;
- Fykenets;

- Fences; and
- Traps inside fenced plots.

One farm plot (0.1ha) in each village was surrounded by scare lines made of pieces of plastic or palmyrah leaves inserted in 5 mm HDPE rope. These scare lines were totally ineffective and all the seaweed was eaten by rabbit fish.

In the hope of catching the rabbit fish before they entered the farm, one plot in each village was surrounded by four fyke nets with long leaders (*Fig.5*). The opening of the fyke nets and the leaders were 1m in height. However, rabbit fish swam over the leaders and into the farm plot rather than following the leader into the trap. In Vedalai, the height of the leaders was increased to 2 m. Initially, this seemed to work with the leaders protecting the seaweed and the fish getting caught in the fyke nets. But after some time fish began entering the plots again, as evidenced by grazed seaweed.

All rabbit fish were less than 100gm, with the majority below 40 grams. Clearly, the seaweed farms were sited on the feeding grounds of the juveniles of the principal grazing species! Culture trials by CMFRI on the offshore islands in the 1970's experienced little or no grazing (Krishnamurthy, personal communication). This is probably because adult rabbit fish inhabit the offshore fringing reef and do not venture into the shallow lagoon areas.

One plot of 0.1ha in each village was then enclosed with extruded plastic mesh to exclude grazers. Care was taken to ensure that about 50 cm of the fencing extended above the high water mark. The foot of the fence had to be buried in the sandy bottom to prevent it from lifting off the bottom and allowing the entry of grazers. In Chinnapalam, the fence was partly destroyed by high winds, strong currents and drifting *Sargassum*. In spite of repairing the fence and removing the fish from the pen, growth of seaweed remained poor. The fence effectively excluded rabbit fish at Vedalai. **A few entered under the fence, but could be controlled with traps.**

Fig. 5 Fykenet

