EXPLORING THE POTENTIAL FOR SEAWEED FARMING IN MILNE BAY PROVINCE, PAPUA NEW GUINEA

Introduction

Milne Bay Province (MBP) lies at the far eastern tip of Papua New Guinea (PNG) and is dominated geographically by its marine environment. It has a maritime area of approximately 110,000 km² and contains some of the most biologically diverse and pristine coral reefs, mangrove forests, and seagrass beds in the world (Sekhran and Miller 1994; Piddington et al. 1997; Allen and Werner 1998; Allen et al. in press). The majority of the province’s approximately 210,000 inhabitants live in coastal or island communities. They are predominantly matrilineal (i.e. clan membership, territorial rights and inheritance are determined through the female birth line), and rely mainly on fishing, trade and subsistence agriculture for their food security and livelihoods. The pressure exerted on marine resources is increasing given the burgeoning population of the province (currently growing at 2.5% per annum), the increasing desire for cash, the effects of droughts in recent years and the decline in traditional income sources such as copra. Average annual income per household has been estimated at USD 130.00 (Kinch 2001a; Mitchell et al. 2001).

To mitigate the possibility of fisheries decline, there is a need to develop alternative livelihoods and income sources for coastal and island communities. This is considered a prerequisite to achieve sustainable marine resource harvesting in MBP. As a development, seaweed farming requires only a small capital outlay, allows for flexibility of commitment, and has low or nil environmental impacts (see Luxton 2002). Also, the sun-dried product can easily be stored for more than one year, making production particularly suitable for coastal and island communities where transport arrangements may be sporadic. Seaweed farming and other mariculture initiatives can involve all sectors of the community and is equally undertaken by men, women and the aged; and at an individual, household, group, or community level.

Following a recent study by the Food and Agriculture Organization (FAO), MBP was designated a priority for seaweed farming development in the Pacific (see Luxton 2002; FAO 2002).

Seaweed markets

The continuing success and growth of seaweed farming, particularly for the carrageenan industry (see below) is largely due to the mariculture development of the red seaweed *Kappaphycus/Euchema* spp. The farming of *Kappaphycus/Euchema* spp. has now been established as a successful industry for over 30 years in Southeast Asia — which accounts for 80% of all production — and there is a growing interest within the Pacific. This seaweed has proven to be far superior to other seaweeds due to its ease of cultiva-
tion and its tolerance to infection. The availability of the export market, coupled by the short-term nature of the crop (six weeks) and the life-span (two years) of the dried product, makes this particular commodity attractive for development to coastal and island communities. Overall, the industry has shown good sustained growth, and is predicted to continue growing at an average rate of between 5% and 8% per annum (Luxton 2002).

The majority of colloid manufacturers (the extraction of valuable chemicals from seaweed to give viscosity, gel strength and stability to liquids and liquid mixtures) are concentrated in Western countries. Currently three multinational buyers (FMC Biopolymer (USA), CPKelco in Denmark (a division of Hercules Inc. USA) and SKW Biosystems SAS (France)) dominate the market (FAO 2002).

The international marketing of colloids has never been a constraint to any new developments in seaweed farming in the Pacific. In fact, the three multinational processors mentioned above have actively sought and encouraged more production from Pacific Island countries by providing technical assistance, at their own expense, to new producing countries (see below).

Forward supply and price agreements with foreign buyers have been an important factor in the production growth, providing certainty of sales on a world commodity market characterised by cyclic fluctuations in supply and demand. Such agreements not only guarantee the sale of product irrespective of Southeast Asia’s production, but also provide the necessary price security and protection for farmers and exporters embarking on a new development. Such agreements inevitably afford some exclusivity to the buyer for a specified term; in return, the producer and exporter benefits from having no marketing costs at the important stage of trying to establish an economic level of production (Luxton 2002).

Uses of seaweed

Extracts derived from seaweed are used extensively in the pharmaceutical and medical industries where they are used for health, dental and skin-care, and in cosmetics; and by food industries, which use extracts as a stabiliser, thickener or gelling agent. “Thalassotherapy” (or “algotherapy”) baths has also been revived in recent years and has also developed into a major tourism industry.

Agar

Agar is manufactured from certain species of red algae (Rhodophyta) such as Gelidium spp., Gracilaria spp. and Pterocladia spp. Species of Gracilaria are more plentiful, more widely distributed and easier to cultivate than are Gelidium spp. and Pterocladia spp., which do not readily respond to mariculture conditions, and are not easily harvested as are the carrageenophytes.

Agar is the most expensive of the seaweed extracts, owing to its relative scarcity and its specialised applications. It is able to bind considerable quantities of water to form a gel substance that is soluble in hot water but becomes water insoluble at room temperature. The relative gel strength of agar is four to five times that of any other phycocolloid. Its neutral status also enables it to be used extensively as a culture for medical and plant tissue applications. Agar is used in canned pet foods, as a gelling agent in confectionary, and also in the prevention of dehydration of confectionery bakery products. Because it is capable of withstanding the sterilisation process, it is also utilised as a preservative. Agar is the main constituent of microbiological bacterial culture and as such is in high demand within the medical research and development industry. The major focus here is the potential utilisation of polysaccharides for medical treatments for such diseases as cancer, angina, and HIV (the virus that causes AIDS).

Carrageenans

Carrageenans are obtained from red seaweeds (Rhodophyta) such as Gigartina spp., and some species of red algae, principally Kappaphycus alvarezii/Eucheuma cottonii, E. spinosum and Chondrus crispus. Carrageenans resemble agar.
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Among all the phycocolloids, carrageenans have by far the widest application in the food industry. They are principally used in ice cream, milk-based foods and drinks, milk and water-based desserts, protein-based foods, and fruit juices. Beverages such as beer, bakery products, dietetic food, dressings and sauces, and frozen food are also among the products that may incorporate carrageenans, acting as thickeners, stabilizers and emulsifiers.

**Alginate**

Alginate is present in most species of brown seaweeds (Phaeophyta) and is the most widely used seaweed colloid. Alginites are used for their water retentive, gelling, emulsifying and stabilising properties and as low-priced viscosifiers. They are used to prevent water leakage from frozen fish during thawing, or to prevent the degradation of starch. Furthermore, alginites will stabilise oil-and-water emulsions, such as mayonnaise, and suspensions of finely distributed solid material in water, such as some salad dressings. A developing field of application is in restructured food such as crabsticks and onion rings, and the pimiento stuffing of olives.

**General health and nutrition**

There are an estimated 100 edible species of seaweed (see Novaczek 2001a, b; Novaczek and Athy 2001) that can be eaten either raw, dried or cooked and can offer alternatives for better nutrition for coastal and island communities in MBP. The main seaweeds traditionally consumed by coastal and island people of MBP is *Caulerpa* spp., *Sargassum* spp. and *Turbinaria* spp. Depending on the species, seaweeds can contain calcium, iron, agar, carrageenan, algin, iodine, folic acid, vitamins A, B and C, micro-nutrients, laminarin, carotene, potassium, mannitol and fucoidan. These elements or a combination thereof, are beneficial to the human body by: helping lower blood pressure, cholesterol and sugar levels; preventing blood clots; fighting against tumours; removing intestinal worms; treating goiter, bronchitis, stomach ulcers, colds, diarrhoea and constipation; removing shellfish poisoning; inactivating HIV; and removing lead and radioactivity from your body (see Novaczek 2001a, b). Some species can also be dried for use as a dressing for cuts and burns.

**Seaweed farming for Milne Bay Province**

In late 2001, an international seaweed consultancy firm based in New Zealand conducted a survey in MBP for FAO. Due to time constraints, only the group of islands around Samarai were surveyed, but there are several positive indicators to the socioeconomic viability of seaweed farming in coastal and island communities of MBP. This is because initial investment costs are low, farming methods are straightforward and with up to five to six harvests per annum there is rapid return on investment. The level of net household incomes from farming could be expected to be well above the current net household income and will outperform copra production as a cash-earning alternative at particularly fertile sites (Luxton 2002). It can also replace income from beche-de-mer, which is showing evidence of harvesting pressure and decline in some areas (see Kinch 2002a; Skewes et al. 2002) resulting in a more predictable and sustainable cash income from an activity that can fully involve both women and men. Production could also be a part-time activity, allowing time for other activities such as subsistence fishing, gardening, other domestic duties and cultural activities.

MBP was chosen as a priority by FAO because of its geographical diversity. Therefore, a large number of sites could prove to have suitable physical characteristics and potential sites should have the following features:

- Large areas (more than 1 ha) of shallow water (1–3 m depth) adjoining or in close proximity to population centres;
- Shallow water areas with a soft coarse substrate, with few coral heads;
- Exposure to prevailing south-easterly winds, with a fetch distance of more than 5 km to any south-easterly wind barrier;
- Large areas (more than 1 ha) of shallow water (1–3 m depth) adjoining or in close proximity to population centres;
- Shallow water areas with a soft coarse substrate, with few coral heads;
- Exposure to prevailing south-easterly winds, with a fetch distance of more than 5 km to any south-easterly wind barrier;
Protection from direct storm wave exposure by a barrier reef or small islands;

As far away as possible from any freshwater runoff from the land (Luxton 2002).

*Kappaphycus/Eucheuma* spp. can tolerate sea surface temperatures from 21–31°C, but optimum growth occurs at 26–27°C (FAO 2002) and, therefore, will be probably more suited to areas in southern MBP as Davies et al. (1997) have recorded high sea surface temperatures in the northern MBP, particularly around Goodenough Island, causing extensive coral bleaching.

Areas with strong tidal currents and upwellings are also likely to provide suitable conditions for raft and longline culture at numerous locations as they provide the necessary water movement for growth, but also provide water mixing, which minimises the possible negative impact of freshwater runoff. Fast growth is obtained only where there is a high level of water movement, either from wind-driven wave action or strong tidal currents. Plants in a favourable environment can exhibit rapid growth with mean relative growth rates as high as 10% per day. Shallow-water flats in close proximity to mangrove communities and seagrass beds limit farming development because of predation from schooling *Siganus* sp. (rabbitfish) (see Luxton 2002).

Site selection for introduction of seaweed farming in MBP could be assisted by the satellite imagery and the environmental data obtained from the 2001 stock assessment for sedentary resources that was conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the National Fisheries Authority (NFA), and Conservation International (CI). This survey collected substrate data at 1126 sites across MBP (see Skewes et al. 2002). This data will be important because many environmental parameters that determine commercial viability can only be ascertained by using the seaweed as a biological indicator of site conditions over at least a twelve month period.

**Current activities and expertise**

In November 2002, the Secretariat of the Pacific Community (SPC), in conjunction with the Solomon Islands’ Department of Fisheries and Marine Resources (DFMR), conducted a seaweed farming workshop. The workshop was funded by the European Union’s (EU) Rural Fishing Enterprises Project with assistance from FMC BioPolymer. Mrs Jane Bagita, a Milne Bay provincial Fisheries Officer, was supported by NFA to attend the training as an observer, where she acquired skills in seaweed farming, processing and transfer this knowledge and necessary skills to potential farmers in the field (see Ask n.d.). Since her return, Mrs Bagita has been a driving force in trying to develop seaweed farming in MBP for the benefit of village people.

Mrs Minnie Bate is an herbalist and the Director of Pomins Limited, which produces a range of herbal medicine products under the trade name Gemins®. Mrs Bate recently attended the Sea Plant Product Development Workshop conducted by EcoWomen and sponsored by the United Nations Development Program (UNDP) and the Sea Plant Workshop as part of the Pacific Sustainable Livelihoods Program. Mrs Bate is the first person in PNG to venture into herbal medicines based on traditional knowledge of plants and is an active member of the Traditional Medicine Workshops, which are conducted annually by the PNG Health Department. The market perception is that seaweed extracts as natural products provide desirable properties for skin and health care. Pomins is currently using *Hydroclathrus* in its Face and Body Care Cream. Because of the lack of availability of *Kappaphycus/Eucheuma* spp.,...
Pomins is currently trying to source it from the Solomon Islands or Vanuatu and wish to see it grown in MBP.

Conservation International (CI) has been contracted by UNDP to execute the Milne Bay Community-based Coastal and Marine Conservation Program (CMCP). The CMCP constitutes the first large-scale marine conservation and resource management initiative in PNG. It is intended to be a 10-year program assisting many communities in village-based marine resource management and conservation activities aimed at the betterment of their livelihoods. CI, as part of this aim, may investigate alternative income generation and seaweed farming and other mariculture initiatives. By providing an alternative income source for coastal and island communities seaweed farming in MBP could actively promote the future success of this program. The Asian Development Bank’s (ADB) Community-based Fisheries Development and Management Program and the EU’s Rural Coastal Fisheries Development Program are also targeting MBP for fisheries development, which seaweed farming could be subsumed in. CSMC is constructing a multi-purpose hatchery at Samarai Island. The hatchery biologist for CSMC has several years of experience at growing seaweed, mainly *Gracilaria* spp. in Australia as a food source for the abalone fishery. This expertise could be easily utilized with financial and technical support from the above programs.

**Environmental impacts**

Seaweed farming is environmentally friendly on shallow reef flats because the sandy reef flats provide suitable sites for off-bottom farming generally have a paucity of marine life compared with reef fringes, due to the lack of a fixed substrate. Farming structures provide the stable substrate for the growth of seaweed, and enable the large production of organic plant matter in a relatively small area. This controlled increase in primary production increases the food supply and substrate availability for benthic fauna and fishes in and around the farming area. In this respect farms act much like fish aggregation devices (Luxton 2002) and increase local biodiversity and food security for coastal and island communities.

As in agriculture, seaweed farming and other mariculture initiatives will suffer from natural phenomena that cannot be controlled, such as cyclones and El Niño Southern Oscillation (ENSO) events. ENSO influences coastal marine environments because the pressure gradient reverses and becomes negative for a prolonged period with a consequent shift in climatic and oceanographic conditions. This major climatic shift produces change in the established current patterns, causing unseasonal droughts and rains. This aggravates environmental stress and can produce conditions unsuitable for seaweed farming because of higher sea surface temperatures, the reversal of prevailing winds, and increased rainfall.

To develop seaweed farming in MBP there will be a need to initially import seaweed from already producing countries. Seaweed in the Gilbert Islands and Fiji Islands, has for a number of years, been contaminated by a small *Polisyphysia* sp. epiphyte that smothers the host when plants are stressed by poor growing conditions. It is absent in Kiribati and probably from other Pacific Island trial sites such as Vanuatu and Cook Islands. The current stock condition and relative low stock levels make Vanuatu and Cook Islands unsuitable as “seed” stock exporters. The best opportunity for MBP is to import healthy seed stock by air freight from Bali or possibly Biak (FAO 2002). This will ensure that the *Polisyphysia* sp. epiphyte is not introduced. Holding initial seed stock in land-based seawater systems, such as the multi-purpose hatchery established by Coral Sea Mariculture (CSMC) at Samarai would allow for a close inspection of plants before commencing in situ growth trials. Finally, as only vegetative cuttings are grown, the plant is devoid of any holdfast and consequently cannot attach itself to any natural substrate.

**Conclusion and further directions**

From both an environmental and a socioeconomic viewpoint, the potential for successful farming development in MBP is far greater than that in other Pacific countries (Luxton 2002; FAO 2002). While the marine environment of MBP is currently in an excellent and mostly pristine condition, overharvesting of some marine resources and the decline in traditional cash crops causes concern for the future. Developing alternative income sources is particularly important now, as a recent stock assessment revealed that some species of beche-de-mer and giant clam are heavily overfished in some localities (see Skewes et al. 2002; Kinch 2001b, 2002a, b).

Seaweed farming is an environmentally sustainable activity, and has the potential to reduce the catch of marine resources for income generation. Any new income source in coastal and island communities is also likely to reduce the future need for some to resort to illegal (such e.g. hookah gear) or destructive harvesting of marine resources.
Seaweed farming has been shown to provide a better return for effort than copra production on other Pacific Islands, and the same would be true for MBP for those communities with suitable habitat nearby (Luxton 2002).

Successful development in MBP will take two to five years and require considerable financial assistance. This could be sought through the forthcoming ADB, EU or CI programmes with cooperation from the PNG national and provincial government fisheries, private enterprises such as CSMC, and other organisations such as the CSIRO, Queensland Department of Primary Industries, Environment Australia, FAO, SPC and the WorldFish Center. This would also promote regional cooperation on technical aspects of seaweed farming in the Pacific.

Currently, the MBP has a small private sector, with few local entrepreneurs having the necessary capital or experience to risk investing in a new unknown commodity. There will therefore be a need to establish the business infrastructure and/or support from the private sector at the outset of any commercialisation programme. CSMC, or current dried marine resources exporters such as Kiwali Exports, Asiapac and RFI, could be involved. Alternatively, NFA in conjunction with the Milne Bay Provincial Fisheries Division could negotiate with multinational buyers, though given the past performance of government involvement in business, this avenue is not overly satisfactory. Getting exports to market should not represent any problems because there is a very accessible shipping freight system and existing port facilities at Aotau and Samarai. Subsequently the most cost-effective export freight rates could be expected by back-filling boxes to Sydney for onward shipment to processors in Europe or Asia (Luxton 2002).

Before there is any development in seaweed farming there will be a need to conduct an assessment of alternative livelihood options, identification and scoping of possible seaweed farming and mariculture projects, followed by the implementation of a pilot seaweed farm as an alternative livelihoods project. This is deemed necessary because it may take several years to build farmer confidence in a completely new activity, and change work habits away from more traditional income-earning activities, such as copra production and beche-de-mer collection. There would also be a need to undertake site selection surveys and establish and monitor growth rate trials to introduce Kappaphycus/Eucheuma spp. at selected sites. There will also be a need to develop further education and training in identifying different plant responses and morphological changes, and to analyse lessons learned from other project areas. Finally, it is vital that any alternative livelihoods project based on seaweed farming or other mariculture initiatives, be well supported by adequate and continuing funding. This would have a positive effect in reducing poverty and protecting the marine environment of MBP by reducing reliance on declining marine resources.

References


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