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THE PROGRESS OF AQUACULTURE DEVELOPMENT IN FIJI

By

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&

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SUMMARY

Fiji is a country in which aquaculture is not a traditional activity, in contrast to other places in the Pacific and in Asia. Since the 1950's aquaculture has been promoted as a way to add to the range of opportunities for rural communities to be involved in the cash economy. Fiji's progress to develop an aquaculture industry has come a long way since the 1970's, and Fiji now leads the Pacific island developing countries in terms of aquaculture development and diversification.

The breakthrough was tilapia farming, which was the first form of aquaculture to make the leap from technical success to economic success and really take root in Fiji's private sector (at both commercial and subsistence levels). Established tilapia farms can now diversify into freshwater prawns *Macrobrachium rosenbergii* subject to availability of post-larvae. *Kappaphycus* seaweed farming is now re-established after an earlier false start, but faces problems in making payments to farmers and getting dried seaweed to Suva. Saltwater shrimp farming continues to be profitable for those few involved but expansion is constrained by lack of post-larvae and broodstock. A range of other projects have enjoyed technical success and work is continuing to bridge the gap into economic success for those projects too. Fiji can be regarded as being at a consolidation and diversification phase in its development of an aquaculture industry.

Efforts by Fisheries Division of MAFF have so far mainly focused upon the **development** aspect (especially research and training) of governmental roles in aquaculture. In the longer term, it is desirable that the main initiatives in commercially-oriented aquaculture development come from the private sector (though government always has a role in pre-commercial research & development), while Fisheries Division widens its focus to include the other two main roles for government; to **enable** aquaculture (for example, provide in

legislation for aquaculture licensing) and **regulate** aquaculture (provide for environmental management).

This report provides an overview of aquaculture development in Fiji up until mid-1999, with brief descriptions of the main farming types and farmed species. General characteristics of aquaculture and its constraints are described, to provide a checklist for the prospective developer. Also provided is some background about institutional arrangements for aquaculture in Fiji, and speculation about how these might be further developed so that this new sector of the economy may become better established.

The intention of Government is to return ownership of seabed lands within customary fishing rights areas to the traditional owners, and this represents a legislative opportunity to also explicitly provide for the kind of property rights and security of tenure that is needed to attract investment into the aquaculture sector of Fiji's economy. It will require careful thought and planning to make the most of this opportunity.

In the longer term, steps that still need to be taken to further strengthen institutional arrangements for aquaculture in Fiji, to provide for its consolidation and expansion, include:

- Ensure that any new seabed tenure system under an amended Crown Lands Act can also smoothly provide for allocation of space-occupation and trespass rights over seabed in a way that is appropriate for all sectoral interests in aquaculture;
- Amend the Fisheries Act to validate the position of aquaculture operators in terms of the statutory prohibition in that Act on taking of fish without a licence;
- Amend the Fisheries Act to include a new Part on Management of Aquaculture, to provide for the creation through regulation or licence conditions of a management regime for the environmental aspects of aquaculture;
- Add aquaculture to the list of other fisheries sectors (artisanal, longline, pole&line, etc) that Government collects statistics for;
- Encourage the Aquaculture Industry Association to represent private-sector aquaculture interests and contribute to the aquaculture policy process;
- Identify specific training needs for aquaculture in the public-sector, private-sector, and in the community, and find ways to meet these training needs to strengthen sustainable aquaculture development capacity.

INTRODUCTION

Aquaculture is a new industry to many parts of the Pacific, including Fiji, although it has been traditionally practised in some of the Pacific island countries. Many so-called Pacific "micro-states", trying to stimulate economic development but with meagre natural resources, have identified aquaculture along with fishing and tourism as ways to promote economic growth based upon their natural advantages; clean water and high marine biodiversity.

Progress to develop aquaculture in most Pacific island nations has been disappointingly slow, however, and Fiji is no exception despite its relatively larger size and its many infrastructure advantages. Many years of work to develop aquaculture in Fiji now appear to be on the verge of paying off, with some projects already operating commercially and with others in the pipeline. This paper reviews the progress that has been made so far, and also identifies some things that will still need to be done to consolidate the aquaculture industry in Fiji.

A DEFINITION OF AQUACULTURE

Most people have a vague notion that aquaculture is rearing or cultivation of aquatic organisms, much the same as for terrestrial agriculture but in an aquatic medium. It is, however, often necessary to have a more precise definition of aquaculture, because the property rights regime applying to aquatic (especially marine) environments is often very different from that applying to agriculture on dry land. Because confusion is often caused when vague notions of aquaculture are used in situations that demand a precise definition, it will be useful for aquaculture managers and practioners if we first take some time to explore some definitions of aquaculture. The discussion that follows about a definition for aquaculture will become pertinent later on in this report, when we examine institutional arrangements such as the provision of aquaculture property rights in legislation.

There are three main reasons why a definition of "aquaculture" may be needed. Firstly, scientists need to know what processes lie inside or outside their chosen field of study. Secondly, economists need to know what data or statistics to collect and analyse (for example, to compare aquaculture production with fisheries production). Thirdly, a legal definition is needed so that resource managers and resource users can know what rules will (or will not) apply to aquaculture activity.

Aquaculture is usually thought of as being separate from fishing (for example, University courses are often entitled "Fisheries *and* Aquaculture"), with similarities to farming on dry land. A precise yet workable definition of aquaculture has proved elusive, because of the wide range of activities that can fall within it.

A biological definition is provided by Reay (1979): *Aquaculture is man's attempt, through inputs of labour and energy, to improve the yield of useful aquatic organisms by deliberate manipulation of their rates of growth, mortality and reproduction.*

In biological terms, then, aquaculture is human intervention to manipulate the terms of the classic Russell equation for production of biomass from a fish population:

Biomass = recruitment + growth - mortality - harvest

Through investment in an **aquaculture system** (tanks, ponds, enclosures etc) and in appropriate **husbandry**, the aquaculturist attempts to maximise *recruitment* and *growth*, and minimise *mortality*. By contrast, fisheries management is usually an attempt to control only *harvest*.

Bardach *et al.* (1972) showed the wide possible range of aquaculture activities by describing the following seven general categories:

1. Transplantation of aquatic organisms from a poor natural environment to a better environment (for example, oysters or other molluscs);
2. Release into the wild of hatchery-reared juveniles (for example, giant clam restocking);
3. Trapping of naturally-occurring juveniles in or on open-water structures until ready for harvest (for example, pearl oyster or Pacific oyster cultivation on rafts);
4. Trapping of naturally-occurring juveniles in or on open-water structures and cultivating them (for example, sea-cage farming of groupers or tuna);
5. Release of hatchery-reared juveniles into or onto open-water structures and cultivating them (for example, sea-cage farming of snappers or groupers);
6. Trapping of naturally-occurring juveniles in closed waters and cultivating them (for example, milkfish in ponds);
7. Release of hatchery-reared juveniles into closed waters and cultivating them (for example, penaeid shrimps in ponds).

A biological definition, however, says nothing about the flow of benefits from investment in a aquaculture system. This is a crucial point for an investor, who must be able to capture most of the benefits of their husbandry or else go bankrupt. Accordingly, Reay (1979) goes on to give an economist's definition: *Aquaculture is production of aquatic organisms from the basis of site leasehold or stock ownership.*

This narrows aquaculture down to situations where there is exclusive ownership of or access to fish, so that benefits flow chiefly to the investor rather than to any free-loaders. It rules out re-stocking of common-property fishery resources even though, in biological terms, the same processes are involved. This is an issue that FAO has struggled with, in its attempts to record aquaculture statistics separately from capture-fishery statistics.

Legal definitions of aquaculture are also necessary, because the scope of laws applying to aquaculture need to be set out. For example, harvest of fish from a marine farm often has a less restrictive compliance regime (such as no size or tonnage limits) compared with harvesting the same species from a wild fishery.

However legal definitions of aquaculture activity are very difficult to narrow-down without causing anomalies. Biological definitions (like those above) are unsuitable as legal definitions because they are very broad and overlap with pure capture fisheries, or say nothing about peoples' intent. For example, a person throwing away some bread into a pond could be defined as "fish-farming", when really they are just dropping some uneaten lunch. A fisherman could apply for a "farm" to escape size or tonnage limits, without any intention of investing in the various inputs that make aquaculture more productive than fishing. Such inputs are a matter of degree; at what point do we consider that an activity is "farming" rather than "fishing"?

Economic definitions are also unsatisfactory from a legal viewpoint, as they do not cover non-profit aquaculture (where objectives may be social or environmental), nor do they cover aquaculture where fish harvests are not exclusively controlled (such as re-stocking a common-property fishery).

The best attempt to cover all these bases is the new Food and Agriculture Organisation (FAO) official definition, which reads thus: "*Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture while organisms which are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of fisheries.*" (FAO, 1999a). It can be observed, however, that this new FAO definition of aquaculture is really no more robust than any of the earlier attempts, since all it has done is pool together several different definitions, each taken from a different perspective (scientific, economic, or legal).

These definitional issues have not yet been any cause for worry in Fiji or other Pacific islands where aquaculture is still in its infancy, and where the compliance regime attached to capture fisheries is not very strict anyway. However they will become relevant in the future if, as in Australia, New Zealand, Japan and other places, aquaculture takes its place alongside capture fisheries as a major economic activity that shares the same resources but is managed under a separate legislative or property-rights regime. When the time comes for Pacific island governments to legislate for aquaculture, they will need to put some thought into this issue. If they simply adopt the definitions used in the aquaculture legislation of other states outside the region, they will sooner or later encounter the same problems these states are now having in trying to integrate aquaculture management with stock enhancement and fisheries management.

In fact, the best way to look at aquaculture from a legislative perspective is to focus on the *property rights* that are involved in it. To focus on the *activity* of aquaculture is useful only to paint a general picture to the layperson of the things that aquaculture might include. The range of all possible permutations for aquaculture activity defy definition in terms of what aquaculture *excludes*, because in practice aquaculture activities form a continuum with capture fisheries.

Unlike activities, property rights *can* be clearly defined in law. The principles of land law have been around for centuries. Aquaculture can be legally provided for in terms of a particular set of property right elements that need to be acquired in order to carry out the activity. These fall into three categories:

(1) **A right to harvest fish.**
A right to harvest fish may stem either from ownership of the land that the fish live over, or from grant of a statutory licence (like a fishing permit).

(2) **A right to occupy space**
All aquaculture farms (and even a part of fishery re-stocking processes) need to be located on a site. The right to occupy a site may be obtained by purchase of free-hold or leasehold land, or by lease or licence for public land vested with the state.

(3) A right to cause environmental impacts within acceptable limits
If statutory permissions are required for any aspect of the aquaculture operation (for example, to discharge effluent from the farm), then permission will need to be granted through a process to determine that any environmental impacts are within acceptable limits.

Because aquaculture property rights are a bundle of rights that merge with fishery property rights, and because the difference is a matter of degree, a robust legal definition of aquaculture (as distinct from fishing) based on property rights will still remain elusive. By following this approach, however, it is possible to legally provide for and enable aquaculture in a generic way, and thus avoid the need for a precise legal definition in the first place.

As far as a definition itself is concerned, really the most that one can say about aquaculture is that: *An aquaculture right is the right to establish a more exclusive type of fishery with fewer restrictions on catch.*

AQUACULTURE BENEFITS AND CONSTRAINTS

Aquaculture has some theoretical advantages compared with agriculture, however in practice there are some severe constraints that help to explain why progress has been difficult. Pacific island developing countries have a unique set of circumstances which can increase the difficulties. The advantages and disadvantages of aquaculture are explained below, from a Pacific island perspective.

Theoretical advantages of aquaculture

Aquaculture has some theoretical advantages when compared with agriculture. The biological basis for these advantages is as follows:

1. The bodies of fish are supported by water, so less energy is spent supporting their own weight or in normal movement and so more energy can go into growth.
2. Being generally cold-blooded, less energy is spent on thermo-regulation so more is available for growth.
3. Fish have a higher percentage of edible tissue (40 - 70% in finfish, 100% in many molluscs), because much less bone is needed for skeletal support.
4. Fish are much more efficient converters of food protein into bodymass than poultry, pigs, sheep, or other livestock.
5. Aquaculture is a 3-dimensional use of space in the water column (agriculture is usually only 2-dimensional).

Using Fiji as a base for aquaculture brings some additional advantages, which Fiji holds in common with several Pacific island countries (Bell, 1999). These are:

1. Fiji has a high diversity of marine species, many of which have high value in overseas markets for seafood, pharmaceuticals, or aquarium fish;
2. Fiji has a central location in the Pacific that is at the hub of Pacific air and sea transport routes to metropolitan countries of the Pacific rim;
3. Fiji has a large number of potential aquaculture sites, owing to the huge area of sheltered lagoon waters in the Fiji island archipelago;
4. Fiji has a relatively cheap labour force, along with few competing economic opportunities in rural areas.

Practical disadvantages

Despite the theoretical advantages of aquaculture, there are some practical disadvantages which explain why it has not become as pre-eminent an economic activity as agriculture or fishing. Constraints on aquaculture can be technical, socio-economic, and environmental, and many of these constraints are particularly marked in Pacific island developing countries though certainly are not unique to these countries.

Technological constraints -

Aquaculture is a medium to high-risk activity. The risk, compared to terrestrial agriculture, stems from dependence upon the aquatic medium for rearing, which means that: one cannot directly observe animal health and well-being; the activity is vulnerable to natural disasters like floods, heavy swells or cyclones; and diseases, pests and pollutants are easily dispersed.

Weakness of available technologies. For many species, farming methods are still in their infancy and the target organisms are not yet well studied. Many species with potential for aquaculture in Fiji are considered only "potential" because of technical problems that still remain to be solved.

Lack of fish food. In aquaculture, it is necessary to provide protein in order to harvest protein (this has been termed "the fishmeal trap"). Many aquacultured species are carnivores with high dietary protein requirements, yet in the Pacific island countries animal protein is especially scarce. If food of sufficient quality cannot be obtained locally then there will be dependence on expensive imported fish foods.

Lack of spat/fry. A consistent supply of new fish stock is needed to keep the farm running, and this is a constraint which, depending upon the species, can be technically demanding to overcome.

Lack of trained personnel. Fish farming requires biological knowledge and understanding of culture requirements, plus technical skills in operation of equipment and skills in small-business management. Some of these skills are lacking even in more-developed countries, and are particularly scarce in the Pacific island developing countries.

Lack of supporting infrastructure. Many forms of aquaculture require engineering services, biological expertise, refrigeration, or processing facilities, in addition to such fundamentals as electricity, water supply and telephone. Fiji is considered to be one of the more developed of the Pacific island countries, however this description applies only to the coastal rim of the two main islands, Viti Levu and Vanua Levu. Fiji's outer islands and interior share the same infrastructure constraints as anywhere else in the Pacific.

Socio-economic contraints –

Sectoral competition for allocation of scarce resources. Aquaculture places demands upon resources which may be publicly or communally owned, for example, coastal space, or wild-caught juveniles for seedstock.. Aquaculture structures may be considered unsightly. Aquaculture may conflict with alternative uses of the coast, such as fishing or tourism.

Distance from export markets. Pacific Islands are isolated by ocean, and transport costs to export markets are very high. The time taken to reach destinations can be a problem for export of live organisms. Any fisheries products from Pacific island countries will be competing with similar operations in Phillipines and South East Asia that are much closer to the important Japan, Taiwan and Hong Kong markets for high-value seafoods.

Small domestic market. The local market for seafood is relatively small and for the most part unwilling to pay top gourmet prices, however the exception is Fiji's tourism industry which represents a good local marketing opportunity for selected aquaculture products.

No aquaculture tradition. In Fiji, and in some other Pacific island countries, aquaculture is not a traditional activity. It can be hard to convince local communities that they should integrate aquaculture into rural and subsistence lifestyles, where it must compete for their time with other subsistence needs and community obligations.

Poor management and planning. Often developers concentrate on the technical aspects of production and find out too late that market volumes or prices are insufficient to sustain the operation. Ventures must be market-driven, and large-scale production should not begin until market studies are complete. There has been a poor past record of success with aquaculture in the Pacific island countries, though this trend is not unique to the Pacific. Various writings by Uwate and Kunatuba (for example, Uwate 1984) provide case studies of regional failures, and analysis of the reasons behind them.

Use of public or communal lands. Aquaculture in the marine environment of Pacific islands needs to occupy space over seabed "lands" that, depending upon the country, will be vested either with the state as public lands or with traditional owners. Fiji currently has a marine tenure system where ownership of seabed lands is vested with the state, while rights to harvest fish within demarcated fishing rights areas (*qoliqoli*) are vested with traditional owners. In 1999 the outgoing SVT government embarked on a process to return ownership of seabed lands to traditional fishing rights owners, and this has arisen again in the new 2000 interim Government's "Blueprint for the Protection of Fijian & Rotuman Rights and Interests, and the Advancement of their Development" (Daily Post 14 July 2000). It is not yet clear what form this new tenure system might take.

Lack of legal support. In Fiji there is no aquaculture legislation, and no explicit source of property rights for aquaculture other than through private ownership of terrestrial land or ownership of traditional fishing rights. Foreshore leases under the Crown Lands Act can authorise occupation of space in the marine environment, however harvest of fish can only be authorised in terms of the Fisheries Act, which does not provide for aquaculture. As yet, no Pacific island developing countries have passed legislation with provisions for rights-allocation or conflict resolution for aquaculture, or for an environmental compliance regime. There are also institutional impediments to efficient transactions between aquaculture entrepreneurs and communal land or fishing rights owners.

Political instability

Formerly considered politically stable from an investment point of view, Fiji's reputation has been tarnished by the political upheavals of 2000. It is too soon to find out the long-term response of investors; some are still going ahead with projects already in the pipeline,

however investors in some new projects still in their infancy (for example, establishment of new penaeid prawn farming ventures) are adopting a "wait and see" approach. The current situation has both negative and positive aspects for mvestors. On the positive side, Government may relax some requirements and make the investment climate in Fiji more attractive, in order to make up lost ground.

Environmental constraints –

Biosecurity restrictions apply in most South Pacific countries on introduction of exotic species, which means that it is best and easiest to base an aquaculture venture upon a species already present in Fiji. Exports of live organisms will need to meet the biosecurity requirements of the destination country. If the species being cultivated for export is one listed in the Convention on International Trade in Endangered Species (CITES), for example giant clam, then special certification is required before farmed stock of such species will be accepted within the borders of CITES parties.

Environmental concerns. There can be environmental impacts from aquaculture that affect other coastal users, particularly if farms are badly located, badly designed or badly managed. The actual impact depends on the type of aquaculture, and many types are very low in impact, so it is difficult to make generalisations about impacts. Some more serious impacts from aquaculture can include modification of the coastal environment (such as mangrove clearing), waste deposits on the seafloor, nutrient enrichment leading to eutrophication of enclosed waterbodies, spread of fish diseases, visual impacts on scenic values, navigational hazards, and introduction of exotic organisms. These concerns can lead to public and political opposition to aquaculture as an industry, so it is in developers' interests to avoid such impacts. Most major impacts can be identified through Environmental Impact Assessment procedures and can be avoided or mitigated through appropriate farm location, design and management. It is important that there be a responsible attitude by developers, and that there be regulation, monitoring and enforcement by government.

Reasons to support aquaculture

Despite this long list of constraints to aquaculture both globally and in the Pacific island developing countries, and despite the unglowing track record of aquaculture development in the Pacific region so far, support for aquaculture development remains high. It must be remembered that not all the above constraints apply to all types of aquaculture, and many can be avoided or mitigated by appropriate management and planning. They are listed here not to paint a picture of doom and gloom, but because it is important to learn from the experiences of the past so that history does not repeat itself. Meanwhile, the fisheries departments of almost all regional governments continue to identify aquaculture as a priority area for economic development (SPC 1999).

Pacific island governments, including the Government of Fiji, are generally supportive of aquaculture development because they see a need to:

1. Increase the productivity of fishery resources;
2. Ease the pressure being placed upon natural fish stocks. Many high-value inshore species are severely depleted in some areas (for example giant clam, spiny lobsters, groupers, beche-de-mer) because of high demand and relatively easy access;

3. Reduce imports and place greater reliance on local resources, to save foreign exchange and avoid "leakages"of revenue from industries like tourism. For example, much of the seafood served by resort hotels in Fiji is imported;
4. Increase export earnings, to gain foreign exchange. Aquaculture is a significant export earner for places like Phillipines and Okinawa, and Pacific island countries could follow suit.
5. Increase employment, especially in rural areas to reduce urban drift. Aquaculture requires farm labour, and needs to be sited in clean water away from urban or industrial developments, so it goes hand-in-hand with rural development;
6. Improve food security and human nutrition in many rural areas. For Pacific island countries fish is the main source of protein in human diets, however in the interior parts of high islands like central Viti Levu, fish are scarce. Subsistence-level Tilapia aquaculture is one way to overcome nutritional protein deficiencies in these communities;
7. Support business growth and economic development generally. In theory, the private sector has the best information to bring about economic growth, to generate jobs and income for a nation. A focus of governments, and of assistance from aid donors to the Pacific, is now to provide support for private sector development. Aquaculture can be a useful part of this trend.

Advantages of aquaculture to the private sector include:

1. High-demand food items are increasingly hard to get from capture fisheries (for example, penaeid shrimps, giant clams, tropical groupers);
2. Capture fishery supplies of seafood are often highly seasonal;
3. Capture fishery seafoods are highly variable in size and quality;
4. Markets for fish often have very narrow windows of opportunity. This is particularly true of the Japanese market, where consumption of certain fish is related to festivals and special occasions or where there are times when alternative (such as domestic) suppliers are off-season;
5. Aquaculture can often complement other land use (such as agriculture) and through polyculture can cross-subsidise several ventures on the same land which separately may be unviable;
6. Aquaculture has multiplier effects in the economy as it requires support services in other areas like engineering, feed production, vetinary services, transport, construction, technical consultants, economists, lawyers and equipment sales.
7. Aquaculture can be a profitable business.

The general public is often supportive of aquaculture because;

1. It can be perceived as a more sustainable way of obtaining seafood, rather than depleting natural resources;
2. It can produce a better and more consistent size and quality of product to the consumer than capture fisheries;
3. It provides employment and investment opportunities, and helps rural community development.

HISTORY OF AQUACULTURE IN FIJI

An aquaculture industry has taken a long time to develop in Fiji, and lags far behind the agricultural sector in terms of its contribution to the economy. Worldwide, subsistence-level aquaculture has a history dating back thousands of years, however modem and industrial-scale commercial aquaculture has only developed in the last 50 years.

In the Pacific, there is archaeological and oral-history evidence of fish-farming in ponds on Oahu in Hawaii, and some of the ponds are still operational today. Similar practices have been documented for Cook Islands, FSM, Fiji, Kiribati, Nauru and parts of PNG. However in recent times Fiji can be regarded as a place where aquaculture is not a part of traditional subsistence activities.

Aquaculture, in the modem sense, began in Fiji with the introduction in 1953 of Tilapia fish which were farmed for use as pig food. These fish inevitably escaped and became established in some river systems. Later, in the 1960's, The United Nations Development Programme and South Pacific Commission set up the South Pacific Island Fisheries Development Agency, which funded various aquaculture programmes in Fiji, however, according to Kunatuba (1993), most of these projects did not bridge the gap between technical feasibility and commercial viability as their focus was purely technical and did not adequately consider socio-economic issues. Concerted effort to develop aquaculture industries in Fiji began in the 1970's through government programmes on freshwater and saltwater shrimp, rabbit fish, grass carp, silver carp, and so on. A freshwater aquaculture research station was established at Naduruloulou, on the banks of the Rewa River north of Nausori. A marine aquaculture station was built on Makogai Island, the former leper colony in the Lomaiviti group.

In the 1980's farming of the seaweed *Kappaphycus alvarezii* (also known as *Eucheuma*) was introduced by New Zealand company Coast Biologicals Ltd. Much work went into expansion of this industry only for it to cease in 1993. Also during this time, commercial saltwater shrimp farms were built at Raviravi near Ba (by Fiji Government with overseas partners) and at Navua by Jim and Judy Tilbury. Both are still in operation. A pearl farm was established in Ra and later moved to Vanua Levu. A variety of landbased operations (about seven in all) have been involved in export of live aquarium fish, corals, and coralline algae (so-called "live rocks"). These utilize aquaculture systems and techniques, but can mostly be regarded simply as holding facilities for transhipment of live organisms. Some, however, have been also breeding and rearing aquarium fish so can be thought of as true aquaculture operations.

Aquaculture development in Fiji has received another boost with the introduction by the Ministry of Agriculture, Fisheries and Forests (MAFF) of the Commodity Development Framework (CDF) in 1997. This was accompanied by the reorganisation of MAFF's Fisheries Division to include a new aquaculture programme with three main sections; freshwater, brackish-water, and marine aquaculture. Under CDF, work is being done on the following projects; saltwater shrimp, milkfish, giant clam, pearl oyster, trochus, *Kappaphycus* seaweed, tilapia, ornamental fish, turtles, coral, sponges, freshwater shrimp, and polyculture. Of these projects, the ones now at the commercial stage of development are saltwater shrimp, milkfish, tilapia, *Kappaphycus* seaweed, pearl oyster, and giant clam.

THE MAIN AQUACULTURED SPECIES IN FIJI

This section reviews the main species that have entered into commercial production in Fiji, either by government or by the private sector. The general biological and economic characteristics will be described, along with an opinion about future prospects. The different kinds of aquaculture listed here fall into four main categories; Subsistence-level, Commercial level for domestic sales, Commercial-level for export, and Re-stocking of capture fisheries.

Giant clams (*Tridacna* and *Hippopus* spp.)

Giant clams are unique among animals in that they do not need to be fed at all; symbiotic algae live in their tissues and provide them with the products of photosynthesis, so all they need is clear water with high light levels. They are also filter-feeders, so occupy a low trophic level (this is energetically more efficient). They are sedentary animals which do not need to be enclosed to prevent escape. They have a tough shell, so (above a certain size) are protected from predators. The planktonic larval stage is short (about 8 days), after which they can be settled onto solid substrate and treated like adults (but must be protected from predators). Being self-feeding, they tolerate overcrowding. On the other hand, they are relatively slow-growing and long-lived. There can be very high mortality due to predation by crabs and fish of young juvenile stages when shells are still thin.

High prices are paid for clam meat, both locally and in export markets such as Japan and Taiwan where giant clam sashimi is highly prized. These markets are not large, and could be easily saturated by clam farms in SE Asia. Slow growth increases culture costs, unless clams are outplanted onto reefs again. But here they are vulnerable to theft or cyclone damage. It takes 7 years to grow a 45-cm clam in Fiji. They can be sold for food at smaller sizes than this, but it still takes 5 – 6 years to get a decent-sized adductor muscle for the food market.

It is technically feasible to routinely spawn giant clam in hatcheries and raise the juveniles through to adults, and there is good understanding of cultivation technologies though work continues to optimize culture conditions. Much work on this has been done at MAFF's aquaculture facility on Makogai Island, and at hatcheries overseas (for example, ICLARM in Honiara). At Makogai five species are currently being cultivated; *Tridacna gigas, T. derasa, T. squamosa, T. maxima* and *Hippopus hippopus*. At the time of writing there were about 54,000 3 – 10 cm clams at the ocean nursery stage and another 300,000 or so 1 – 2 cm clams in tanks on land.

Clam aquaculture and restocking depends upon use of reef-flats, which are areas either under customary tenure or vested with the Government in Pacific Island countries. Obtaining exclusive access or exclusive harvest rights, in order to protect farmed stocks, is therefore a major hurdle to be overcome by any investor in clam aquaculture, unless the investors are themselves customary rights holders. It is not economic to rear clams to market size entirely on land in tanks. Fiji Fisheries Division itself sells clams to export markets to defray costs of research, however the market they now concentrate on is the ornamental aquarium market, which takes a much smaller animal size (about 6 cm shell length) than the food market. Clam farms in other Pacific island countries, for example, in Marshall Islands, are now mainly targeting the aquarium market.

Technical problems with clam aquaculture have largely been solved, and the obstacles now are socio-economic and marketing. For re-stocking as a business venture, the margin is slim

between the cost of outplants and their survival to marketable size. Management control of enhanced areas is critical to success, but is not easily achieved. Clam re-stocking as a conservation measure may be justified but will need to be externally subsidised rather than be run as a stand-alone venture,. It will also need to be accompanied by appropriate fishery management of the re-stocked area or else the whole effort will be wasted.

Thorough marketing analyses are still needed to ensure that the expense of clam aquaculture can be justified. The problem is mainly one of getting sufficient price. The ornamental aquarium market for 1 – 2 year-old clams is the most lucrative one at present, but the size of this market may be limited and needs to be determined. Alternative markets are sale of <1-year-old clams as seedstock to other ventures, or sale of 6-10 year-old clams for their meat, however the economics are fairly marginal (Ellis, 2000).

Tilapia (*Oreochromis* spp.)

Characteristics of these introduced freshwater fish species which seem to make them the ideal farmed fish (the "aquatic chicken") are in fact both a blessing and a curse. They are very fast-growing, extremely hardy (euryhaline, withstands low oxygen levels), are herbivorous/omnivorous and eat practically anything; and breed spontaneously in ponds without any need for hatchery technology or special techniques.

On the other hand, there are big growth improvements from use of the correct diet; they breed by digging burrows which lead to erosion of pond or river banks, and the young age of first maturity means early and prolific breeding in ponds causing overcrowding and stunted growth. Once in a pond they are almost impossible to remove entirely, except by poisoning (for example, with derris plant or *duva*). They represent a pest to other aquacultured species, and to young fry of the same species.

Tilapia are not a high-value fish, although, surprisingly for a country that traditionally prefers marine food fish, a domestic market has been established for tilapia in Fiji with prices around $3.00 - 4.00 per kg. There is some potential for export to Australia and New Zealand if appropriately processed and marketed.

Tilapia are one of the best researched species for aquaculture, and there is a wealth of experience in their husbandry. Tilapia are tough and tolerate a wide range of environmental conditions. Since little environmental modification is needed, aquaculture systems can be low-tech. The main function of the aquaculture system for tilapia is to isolate the population, to prevent escape or predation losses, prevent competition for added food with other species, to control breeding (by separating males from females), and to keep the fish all in one place to make harvesting easier. Any earthen ponds in non-flood-prone areas will be sufficient. Concrete tanks or raceways can be used, but are more expensive and usually cannot be justified. Cages in rivers can also be used.

The technique to produce tilapia fish of marketable size at reasonable cost is not as easy as is often believed. All too often the result is large numbers of very tiny fish which never grow and which cannot be sold except as manure. Tilapia have been in Fiji since the 1950's, but only in the last decade have they become a benefit rather than a headache. This has been the result of a concerted effort by Fisheries Division to promote good stock management, and to carry out research on genetic improvement. A joint MAFF/ACIAR genetic improvement

project has identified the Chitrilada variety of *O. niloticus* as the one with the best agronomic traits.

Tilapia farming has been of particular benefit for inland rural areas as a subsistence-level operation to provide better nutrition and food security to inland communities. About 200 small-scale inland farms have now become established. Tilapia is also the basis for industrial-scale farm operations who sell in municipal markets in Fiji and who are now eyeing export markets. There are seven large commercial tilapia farms in Fiji, with four private-sector hatcheries and two government hatcheries providing fry for pond stocking. Fisheries Division statistics recorded production of 242 T of tilapia in 1998, a 17% increase over 1997.

Freshwater prawns *Macrobrachium rosenbergii*

Culture of this species, introduced from Malaysia several years ago, for a time did not progress beyond the trial stage because it appeared to be uneconomic. Freshwater prawns are relatively easy to breed and rear, but the main problem is a lower market price, less flavour and smaller tails compared to penaeid shrimps. Recently, however prices for freshwater prawns have risen to F$15 – 20 per kg farmgate price and F$25 – 30 per kg retail. Trials by
Fiji Fisheries Department using tilapia ponds and tilapia pellet feed have shown good results.

This, and a series of training workshops run jointly by Fisheries Department and The University of the South Pacific with funding from Government of Canada in 2002 – 2003 has stimulated interest in *M. rosenbergii* farming to the point where the government hatchery at Naduruloulou cannot keep up with demand for post-larvae. A twelve-pond farm has been built by Mataqali Rokoraite at Kasavu Village in Tailevu which is profitable and has acted as a model for other similar projects in Tailevu and Naitasiri with pond construction funded under the present SDL government's Blueprint scheme.

Macrobrachium rosenbergii from Malaysia is considered to have better agronomic traits than the main local species of freshwater prawn, *Macrobrachium lar*, however little research has been done on the latter species and the life cycle has not yet been closed. It may yet prove suitable for aquaculture (Nandlal, pers. com.).

Seaweed farming (*Eucheuma/Kappaphycus*)

Originally called *Eucheuma* but now scientifically known as *Kappaphycus alvarezii*, this seaweed is an exotic species introduced from Phillipines via Tonga. It is a major world-wide source of the gelling phycocolloid *carageenan*, which has many food-industry and industrial uses. The establishment and status of the *Kappaphycus* industry in the South Pacific has been previously documented by South (1993). Trials or actual cultivation were conducted in Fiji, Tonga, Kiribati, Solomon Islands, the Federated States of Micronesia, Samoa and Tuvalu during the 1980's, and this led to establishment of commercial industries in Fiji and Kiribati.

Cultivation of *Kappaphycus* in Fiji utilizes the off-bottom method of stakes and monofilament lines (South 1993). Seaweeds are plants (autotrophs - the lowest possible trophic level) so can make their own food from sunlight and nutrients in seawater.

Kappaphycus has rapid growth and can be propagated from cuttings (no breeding is needed). Sexual maturity does not affect growth, and it tolerates overcrowding so long as self-shading does not occur. Plants can usually be harvested after 5 – 8 weeks depending upon variety and location. On the other hand, this seaweed does not like brackish water, needs relatively high amounts of nutrients in the water, does not like choppy seas (plants break up), suffers from "ice-ice" disease if stressed or nutrients are insufficient, can be fouled by other algal epiphytes, and is eaten by herbivorous fish such as siganids (*nuqa*)

The Fiji industry at the time of its peak (277 dry T were produced during 1987) is reviewed in Adams and Foscarini (1990). Cultivation in Fiji ceased in 1993, for reasons that have not yet been fully documented or analysed. It appears that a sequence of stop-start stages in the development of the industry and in the marketing of the seaweed led ultimately to a loss of confidence by seaweed growers. Fiji's exit in 1993 left Kiribati as the only South Pacific nation with an ongoing commercial *Kappaphycus* industry. Kiribati has continued to do well, with production exceeding 1000 T per year.

However in 1997 CDF funding was used to re-establish a seaweed farming industry. With a revolving fund set up to buy start-up equipment and materials, Fisheries Division are now supplying farmers with the necessary materials and will deduct a portion of farm takings until the amount has been paid back. Taking a district-by-district approach beginning with Kiuva (near Suva), 182 farms had been established by the end of 1998. Operated by coastal villagers in their traditional fishing rights areas (*qoliqoli*), the expectation is that another 500 farms will be operational by the end of 1999.

Farming of seaweed is a low-tech process well suited to the lifestyles of rural villagers (see South 1993 for a description of the farming methods). It is a part-time activity that can fit in with other subsistence activities and community obligations. The product can be dried after harvest, which eliminates any need for refrigeration. Seaweed do not need to be given any food. The farming process is well understood and easily demonstrated to farmers. To begin operations, farmers need a boat, an outboard motor, wooden posts, rope lines, raffia to attach plants, a seedstock of living plants, and a shadescreen drying platform. The only drawback is that the farmgate price must be sufficient to maintain grower interest, compared with returns from competing rural income sources like fishing or copra.

Farm gate prices have been around F$0.45 - 50 per dry kg, compared with only F$0.35 at the time that exports ceased in 1993. Initially in 1997 farmers sold dried seaweed domestically to soap manufacturers, for example Mokosoi Soaps Ltd, but demand is only about 2.5 – 3.0 T per year. Meanwhile links have been established with FMC's seaweed processing factory in Denmark. In 1998 21 T were exported to Denmark, and by September 1999 another 120 T had been sent, with an interim F.O.B price (pending longer-term pricing arrangements) of around F$1000 per T. Production has levelled off recently as a result of problems in domestic marketing arrangements, in paticular long delays in payments to farmers and constraints in inter-island shipping capacity for delivery of dried seaweed to Suva.

Value-adding is an opportunity for additional income from seaweed. Dried seaweed is not by itself a valuable commodity, compared to the various extraction products after refining. It would be of enormous benefit if a carageenan refining factory could be built in Fiji, processing seaweed from its own farms and those of surrounding countries in the South Pacific. This will require multi-million dollar investment and, according to industry

advisors, assured supply of 10,000 dry T of seaweed per year. Fiji and Kiribati production combined is still a long way short of this target.

Saltwater shrimp (*Penaeus* spp.)

The penaeid shrimps are one of the most profitable aquacultured commodities but are demanding to spawn in hatcheries, and require a relatively high level of training and infrastructure to breed and grow-out successfully. Larvae need live planktonic food like micro-algae and brine shrimp (*Artemia*) which themselves must be cultivated. Adults need good-quality pellet feeds, specially formulated to meet their high % protein requirements. However there is greater market demand as they have a better taste, larger tail size and more attractive colour than freshwater prawns. They can be grown-out in enclosed ponds, so a farmer can have complete control over stock and keep them entirely within his/her tenure.

Fiji shrimp farming began in the 1970's with construction of a farm at Raviravi near Ba, as a joint venture between the Fiji Government and French interests. This has had mixed success and successive owners, and has been joined by another commercial farm, Navua Prawns Ltd. The latter farm has depended mainly on imports of post-larvae from hatcheries in Australia, but in recent times has tried spawning and rearing their own batches of larvae on-site.
Economies of scale are needed to run a commercial hatchery successfully, but it is important that current dependence upon Australian hatcheries be lessened. Another constraint is the need for importation of pelleted food, because locally manufactured ones are not yet of sufficient quality. Big savings in freight costs and duty will be possible if reliable local sources of post-larvae and pellet foods come on-stream.

The main species cultivated in Fiji has been *Penaeus monodon*, though Fiji is at the southern limits of distribution for this species and cold temperatures during the "winter" months can lead to mortalities. However good results have been obtained with *Penaeus stylirostris* during the cold season, so reliable year-round cultivation is possible using these species in combination. Farm gate prices for Navua shrimp range from F$25 – 35 per kg depending upon size. Domestic aquacultured production is currently around 50 T per annum with a value of F$500,000, however this production is constrained by the availability of post-larvae for pond stocking. If this constraint were removed, existing pond area has the capacity to produce around 100 T (F$1 million) per year.

According to Fisheries Division estimates, total domestic demand for shrimp in Fiji is about 600 T per year. About 400 T is imported, and the rest is supplied by local farms and by capture fishery production. On the basis of projected demand of 0.75 kg shrimp per room per week, there could be demand for 200 T per annum from tourist hotels alone. There is therefore room for expansion of the Fiji shrimp cultivation industry, and potential for export to New Zealand and Australia. Such expansion may be imminent, with three overseas companies having recently lodged applications with the Fiji Trade and Investment Board, however the political events of 2000 may see some of these put on hold for a time.

Species found naturally in Fijian waters include *P. monodon, P. merguiensis, P. japonicus* and *P. indicus.*

The private sector has this year joined with IMR at the University of the South Pacific in the establishment of an experimental hatchery on campus to ascertain the viability of larval production in Fiji. The results so far have been mixed. Broodstock are only seasonally available (October – May) and have seemingly low fecundity, an average spawn being 200,000 eggs and mixed fertility. Fiji is blessed with being "disease free" which is an added advantage to the industry. The common bacterial afflictions exist but the killer viral scourges of White Spot, Yellow Head, Taura, and even MBV seem absent from Fiji waters. This is possibly a temporary reprieve as imports of frozen products from disease ridden sources are alarming local scientists. Ideally there should be a ban on shrimp imports but this is unlikely to happen unless Fiji can demonstrate that the local demand for shrimp can be met by local production, thus the race is on to establish a local viable industry before disease is introduced.

Local feed millers such as Crest are willing to experiment with feed production for shrimp, once farmers can guarantee a certain consumption of the finished product. In the interim, Fiji is dependant on imports of feeds, some of dubious quality.

Since aquaculture of shrimp is in its infancy here, Fiji has the advantage of being able to implement new technology from the start without having to modify existing farms. Aspects presently under study are zero water exchange, or at least greatly reduced water exchange, coupled with experimental round ponds using liners. Further a system of raceways is envisaged thus reducing the time the post larval animals spend in the grow out ponds. Plans are already prepared to close the cycle and domesticate the species.

So far results have shown that Broodstock availability on a year-around basis is a constraint and gravid females from different locations in the island group appear vastly different in size, fecundity and fertility. Further study is presently being undertaken in this area by the University of the South Pacific and by Fiji Department of Fisheries.

In summary, shrimp farming is an industrial-scale operation that requires a high level of investment, expertise, and dedication. It is not well suited to subsistence level or village-based operations unless done as a joint venture with an experienced private-sector partner.

Blacklip pearl oyster *(Pinctada margeritifera)*

Cultivation of blacklip pearl began in Fiji over 20 years ago, but currently there is only one commercial farm plus a government demonstration farm in Vanua Levu. Proposals have been put forward for another two farms to be located in the Lau Group. Constraints have always been the scarce supply of wild oysters in Fiji for stocking of farms, and the lack of local skills in the technically-demanding pearl grafting techniques. Fisheries Division is currently testing the economic viability of setting up spat collectors to obtain pearl oysters for farming, and early results of spatfall have been very encouraging. There are also plans to spawn pearls in a hatchery, as a backup during the off-season for spat collection. Some overseas companies have expressed interest in setting up new pearl farming operations in Fiji.

This must be considered a fledgling industry for Fiji, though blacklip pearl cultivation is well-established in Cook Islands and French Polynesia. The problems of obtaining seedstock need to be solved, and farming will become much more profitable if reliance upon Japanese pearl-grafters can be ended (currently they expect 1/3 of the pearl harvest as payment). Longer-term there is a need for marketing work to ensure that world production

is not in danger of over-supplying markets for black pearls, though this is not a problem at present.

Grass carp *Ctenopharyngodon idella*

Grass carp were imported from Asia in the 1970's to begin a programme of aquatic weed control (such as Water Hyacynth) in Fiji's major rivers. Other carps have also been tried, like Silverbarb *Puntius gonionutus.* The programme has been very successful, and carp stocks in rivers are presently sufficient to control weeds so no further releases are planned. Grass carp is now being cultivated in polyculture with freshwater prawns *Macrobrachium rosenbergii* in a new trial programme.

POTENTIAL NEW SPECIES FOR AQUACULTURE

New species need to be selected only after culture trials to find out if their characteristics make them suitable for aquaculture. Species selection criteria fall under four headings; biological characterisitics, technological characteristics, legal characteristics, and marketing charcteristics. These are explained in more detail below, to serve as a checklist when carrying out a feasibility study for a new aquaculture project in Fiji. It is surprising the number of project proposals that have been put forward by investors without any assessment of the species using a checklist such as this.

The species best suited biologically for aquaculture ideally have the following characteristics:

1. Eurythermal (able to tolerate a wide range of water temperatures)
2. Euryhaline (able to withstand a wide range of water salinities)
3. Able to withstand low DO_2 levels
4. Rapid growth (especially juvenile stages)
5. High fecundity (large number of eggs/fry produced per kg biomass)
6. Closed lifecycle (can be bred and reared in captivity from egg to market size, so recruitment not dependent upon natural phenomena), or ready supply of natural seedstock
7. Young age at first maturity (after gonad maturation, growth almost stops).
8. High food conversion ratios, and low nutritional requirements (eg low % protein)
9. Low trophic level (preferably a herbivore, omnivore or carnivore at 2nd trophic level)
10. Resistance to diseases and pollution
11. Tolerates overcrowding (good social habits; no cannabilistic or territorial behaviour)

Technical factors include:

1. The state of biological knowledge; for example, is there information about lifecycle, breeding methods, environmental tolerances, ideal culture conditions, best food supply, animal behaviour (cannabilistic?). There is no substitute for good information about the basic biology of your organism. Such information must be obtained for any new aquaculture candidate.
2. Availability of proven technologies (culture methods) and products for culture (eg tanks, seacages)

Economic factors that are desirable in a farmed species are:

1. High market demand (high price per kg). Is there an existing market for the species (such as seaprawns)? Could a market be created, for example, through advertising promotions (as for NZ Greenshell mussels)? Is there scope for value-adding through post-harvest processing (for example, smoked or chilli mussels)
2. Low production costs (low inputs needed from farmer)
3. Low post-harvest costs (need for processing or preservation, need to design new technology for this, distance to market, transport costs)

Legal factors include:

1. Can property rights be obtained to provide for harvesting of the farmed stock, that are sufficiently exclusive to ensure profitability?
2. Does current legislation allow farming of that species? Some species may be considered pests, so farming could be totally banned (for example, marron in New Zealand).
3. Can biosecurity laws be complied with? Often a shortcut method of species selection is to introduce into the country an exotic species that has already been successfully researched, farmed and marketed elsewhere. However there may be laws in place to control new imports of the species from overseas (quarantine is required, some species may be totally banned), or to control the introduction of a species to new parts of a country where it does not yet exist.
4. Can health laws be complied with? (such as sanitation requirements, HAACP)
5. Compliance with fishery protection laws. Will the farmed product be exempt from any fishery-oriented restrictions (such as a minimum legal size)?

No species on earth is desirable in all respects, so each must undergo careful assessment to find out whether, on balance, it has enough good points to overcome any shortcomings and justify cultivation under whatever local conditions are prevailing.

In general, the most important factor is market price. Species which would otherwise be most unsuitable for aquaculture can be farmed, if the end price justifies the necessary extra inputs needed to overcome deficiencies in the other areas. Species farmed in spite of technical difficulties include sea prawns (*Penaeus* spp.) and species from high trophic levels requiring very expensive food include tuna (Australia), groupers (*Epinephalus*) and snappers (*Chrysophrys*). Most high-value reef fish are high-trophic-level carnivores.

The second most important characterisitc is growth rate. Despite high market price, slow growth is a major obstacle to aquaculture of many desirable species like groupers, giant clams, and spiny lobsters. Often, biological factors can be secondary in importance to economic factors, but this fact gets overlooked by some scientists when ranking species for aquaculture potential.

The section below describes the aquatic species in Fiji which are not yet commercial, and are of high priority for further research and development. The list is not exhaustive, and other candidates will no doubt appear.

Milkfish

Milkfish ***(Chanos chanos)*** are a marine and brackish-water fish that are a popular food fish in Asia. Though a part of subsistence and artisanal catches in the Pacific, they do not have

high monetary value as food. A potential demand was identified by Fisheries Division in Fiji for milkfish as live baitfish for tuna longline and pole&line operations. Live milkfish baits of 80 - 150 g in size can apparently improve tuna catchability by 70% when used on longlines. Live baits of 40 g size are also useful for handline fishing to catch serranids (groupers like *Plectropomus* spp. or *Epinephalus* spp., for example *kawakawa*) for the lucrative live export market. As part of the CDF aquaculture initiative, Fiji MAFF constructed a demonstration farm at Dreketi in Vanua Levu with 20 ponds covering a total area of 5 hectares, however this is no longer in use for milkfish and at the time of writing is being used by a Taiwanese company to grow *monodon* shrimp.

Milkfish fry can be bred and reared in a hatchery, but it is often more economic to collect them from the wild using scoop nets. Experimentation with collection sites and times has shown that, in Fiji, fry are seasonal (from October to March is best) and easily caught by making shallow pools in the mudflat areas near mangroves. These pools act to aggregate fry during low tide. Year-round fry production in Fiji can be made possible by a combination of wild-collection and hatchery spawning.

More work is needed on the marketing and economics of milkfish farming, to find out the size of the prospective baitfish market and the prices that fishers are willing to pay, before milkfish production can be justified.

Other seaweeds

Candidate species for aquaculture in Fiji include food species like *Caulerpa racemosa* (*nama*), *Gracilaria maramae* (*lumi wawa*) and *Hypnea pannosa* (*lumi cevata*). Some species have potential as sources of gelling phycocolloids, agar or carrageenan. There is also a need for live seaweed to use as food in greensnail aquaculture.

The phycocolloids present in three Fijian species of *Gracilaria, G. maramae* South, *G. edulis* (Gmelin) Silva, and *G. arcuata* Zanardini v. *snackeyi* Weber van Bosse, have been tested by Falshaw *et al.* (1999) and their conclusion was that each of these seaweeds holds some promise as a candidate for commercial agar production, and hence for aquaculture. The *G. arcuata* v. *snackeyi* agar had a higher melting point (ca. 100° C) than conventional agars, which is a useful property for the food industry and is only the second time that a high melting point agar has ever been found in the *Gracilaria* genus. However Kadoya & Co Ltd, a seaweed importer in Japan, said they would consider buying Fiji *Gracilaria* only to blend into other supplies if their existing South American sources became scarce.

The techniques to cultivate these species are similar to those for *Kappaphycus* and are fairly straight-forward. However a market already exists for *Kappaphycus*, but does not yet exist for these other species. Cultivation cannot be justified until a buyer has been found and a price has been established.

Fiji's most popular edible seaweed Seagrapes or *nama* (*Caulerpa racemosa*), and *Meristotheca procumbens* (a red seaweed traditionally eaten in Rotuma) both have a ready market in Japan with high prices being paid. Unfortunately a joint FAO/USP trial of *Meristotheca* aquaculture on Rotuma showed that it is difficult to cultivate (Tanaka, in prep.), while *Caulerpa* is highly perishable and difficult to transport to market (Chamberlain 1998). Cultivation of these species cannot be justified until these technical problems have been overcome.

There are many other seaweed species in Fiji which may have commercial potential, but this cannot be known at present because these other species have not yet been studied.

Sponges

Various marine sponges such as species of the genus *Jaspis* have been the subject of study by the Marine Natural Products Research Group of the Marine Studies Programme at the University of the South Pacific, who are screening them for bioactive compounds that may be useful as drugs in human medicine. Several interesting leads are being followed, however any commercialization of sponge resources will most likely depend upon aquaculture. This is because naturally-occurring stocks will most likely be insufficient for commercial utilization. Fisheries Division have included sponge aquaculture among their new CDF projects.

Most sponges are relatively easy to propagate, but may not be easy to propagate economically. This is because concentrations of bioactive compounds are usually low and are often affected by environmental conditions. Large amounts of sponge material are needed to produce only a small amount of drug.

A recent development, however, is interest in aquaculture of bath sponges, similar to the desirable Mediterranean sponges like *Spongia officinalis*. The FAO South Pacific Aquaculture Development Project Phase II has already funded two sponge surveys, one in Pohnpei and one in Kiribati (Croft 1990, 1995). The sponges of traditional and commercial importance in Pohnpei are *Coscinoderma mathewsi* and *Spongia matamata*, and fieldwork during a recent Sponge Taxonomy Workshop held by the Marine Natural Products Research Group at USP has revealed the presence of *C. mathewsi* in Fiji waters (Michelle Kelly, pers. comm.). These sponges are worthy of further investigation as a potential new industry, as a new economic opportunity for women in rural areas of Fiji, and one that could fit in well with seaweed farming.

Corals

Popular in ornamental aquaria in the US, Europe and Japan, there is already an export trade in live corals from Fiji. Concerns have been expressed both at village level and by environmental NGO's in Fiji about the sustainability of coral harvest, given the importance of coral reef ecosystems in Pacific island countries. During 1999, the Coalition Government was considering a ban on harvest of corals. This issue is mainly one of the *intensity* of harvest, since the harvest for the highly-selective aquarium trade would be but a tiny fraction of the coral lost to cyclones, bleaching events, or boat anchors. Aquaculture would, however, be a good way to defuse this debate, and the economics of coral aquaculture vs. wild harvest are little different (Simon Ellis, pers. com.). A trial of transplanted coral cuttings at Kaba near Suva showed rapid and vigorous growth of transplants. Walt Smith International Ltd has established trial plots near Lautoka and along the Coral Coast, which are growing well.

There is still a sustainability issue in that corals must be collected and broken up in order to establish a coral farm, but, once established, the farm can be self-propagating from its own cuttings using unsaleable rejects. The farming itself is low-tech and appropriate for village-level involvement. This area of aquaculture is to be investigated further by Fisheries Division as a CDF project, and is also the subject of both private-sector (Walt Smith International) and

environmental NGO (Coral Gardens Project) initiatives. The techniques developed for export of aquacultured corals can also be applied to projects aimed at restoration of degraded reefs.

Reef finfish

Many reef fish species have very high value if they can be exported live for the restaurant trade in Asia (especially Hong Kong). Here, they are kept live in tanks for restaurant patrons to choose which fish they want to eat. Fish that are strong and vigorous, and preferably reddish in colour, fetch high prices from US$50 – 100 per kg. Preferred fish are those of the genera *Epinephalus* or *Plectropomus* (groupers, rock cod, coral trout). This market is currently supplied by fisheries in SE Asia and now, because of serial depletion, Australia and the Pacific island countries. These fish are top-order predators, are long-lived, and form easily-targetted spawning aggregations in reef passages, so are vulnerable to over-fishing.

Aquaculture could certainly be justified for such a high-priced species, and is needed in order to relieve pressure on capture fisheries. However their biology makes aquaculture difficult. The fish are technically demanding to spawn on a commercial basis, and have high feed requirements. Grow-out to market size requires a reliable bulk supply of high-protein food, which is difficult to obtain locally in the Pacific island countries. The need for hatchery rearing can be eliminated if it is possible to trap the fish as larvae when they recruit onto reefs from the ocean plankton. Trials in French Polynesia and at ICLARM in Solomon Islands has achieved some success at this, however it creates its own sustainablility issue as the activity is essentially one of fishing for undersized fish. Managers must ensure that juveniles caught for stocking farms are from the larval stages, where there is a natural mortality rate of about 99.999% anyway; collection of larvae can therefore be regarded as sustainable because it "saves" fish from the fate of natural mortality.

Of all Pacific island countries, Fiji is probably best placed to attempt aquaculture of such reef finfish, as Fiji has good supporting infrastructure and has the possibility of manufacturing local feeds from abbatoir waste or fishmeal. Aquaculture of these species must be regarded as still at the pre-commercial stage of development.

Beche-de-mer

Technology to breed beche-de-mer in hatcheries has been developed by ICLARM in the Solomon Islands and animals can now be successfully reared through to a stage suitable for re-stocking onto reefs. Trials have been proceeding of suitable strategies for re-stocking to achieve best growth and survival of replants. The technique and economics of beche-de-mer re-stocking is therefore yet to be demonstrated, but given the heavy fishing pressure in many places and continued high prices paid for beche-de-mer, interest in this project around the region is great.

Freshwater eels *Anguilla* spp.

Eels are farmed in Taiwan and Japan because they fetch high prices in Japan if sales coincide with particular festivals. They need a high-protein diet, and the main constraint is obtaining juveniles for stocking onto farms. Eels cannot be successfully bred in captivity, and farming

relies upon capture of glass-eels or young juveniles from seasonal "eel runs" when the young eels leave their open-ocean planktonic existence to migrate *en masse* up rivers and join the adult populations. Proposals to harvest eel juveniles for aquaculture have caused environmental concerns in countries like New Zealand that have important commercial and traditional fisheries for eels, however progress has been made on this issue in Australia. There is certainly potential for farming of freshwater eels in Fiji, however little information is available on the timing and size of any eel runs in Fiji rivers. Research on this will be needed before any assessment of the potential for eel aquaculture in Fiji can be made.

Spiny lobsters *Palinurus* and *Panulirus* spp.

Spiny lobsters are high value species, however the species available in the tropical Pacific have relatively small tail sizes and are not an ideal colour (red is preferred) to fetch high prices in Japan. Rearing of larval stages in captivity is enormously difficult because of the long larval life (6 – 12 months), so any aquaculture would need to be based upon capture of young juveniles. Growth of juveniles can be relatively rapid, reaching marketable size on 12 – 18 months. Grow-out to market size requires a reliable bulk supply of food with high % protein and high levels of polyunsaturated fatty acids; such food is difficult to obtain locally in the Pacific island countries and is expensive to import from overseas.

Trochus *Trochus niloticus*, greensnail *Turbo marmoratus*,

Trochus and greensnail are harvested in many countries as a source of shell for buttons and jewellery. They can be bred in hatcheries such as the ones in Tonga and Vanuatu, for re-stocking onto reefs. This could be done in Fiji, where it would make a useful new artisanal fishery for rural dwellers. However the economics of re-stocking may be marginal, and justifiable only to restore areas where local extinctions have occurred or to establish populations in new areas. Re-stocking is no substitute for effective management of a fishery. The general comment that can be made about any aquaculture for re-stocking of fisheries is that it can help to remedy *recruitment over-fishing* (where lack of mature adults in the wild has led to insufficient breeding to maintain the population) but is no remedy for *growth overfishing* (where breeding is still sufficient but due to over-fishing the recruits never get a chance to grow very large). In Vanuatu, communities make repeated requests for trochus and greensnail re-stocking but government is reluctant to agree because the effectiveness of current re-stocking trials is yet to be demonstrated.

Mangrove crabs *Scylla serrata*

Mangrove crabs (*qari*) are difficult to rear through the larval phase but as juveniles are hardy and relatively simple to grow-out, though they require a reasonable amount of protein in their diet if growth is to be fast. Prices in Fiji are good at F$40 for a bundle of five medium-sized crabs, and there are enquiries from Taiwan and Singapore about export to those places. Large numbers of under-sized crabs are sold in municipal markets. A growth trial in which under-sized crabs of about 5cm carapace width were fed on trash tilapia at Montfort Boys Town near Suva resulted in good-sized crabs (20cm carapace width) in about four months (Nandlal pers. comm.). There is good potential for an industry in Fiji based upon on-growing of juveniles, and hatchery sources of crab should also be investigated.

Pacific oyster *Crassostrea gigas*

Trials of Pacific oyster in Laucala Bay during the 1970's were not successful, however there are localities within Fiji where good growth of oysters may be expected. Site selection is a key factor in the success of filter-feeding mollusc culture. Sanitation is an issue with any filter-feeding organism that is sold fresh as food, especially in export markets. In Australia and New Zealand expensive water-quality monitoring programmes are funded by oyster and mussel farmers in order to meet export market (especially USFDA) sanitation requirements. There is scope to sell oysters within Fiji to hotels and restaurants, however sanitation will still be a key issue to maintain consumer confidence.

GOVERNMENT OBJECTIVES, AND ECONOMIC VALUE

The size of the economies of Pacific island developing countries is small, and a large proportion of the population are part of the subsistence economy rather than the cash economy. The pool of domestic savings available for investment is therefore small, so Pacific island developing countries rely heavily on foreign investment or external economic assistance to achieve economic growth.

The Government of Fiji, in repeated media statements, has made it clear that it places a high priority upon economic growth, and sees attraction of foreign investment as vital to achieve this. It can be taken, then, that the Fiji Government is generally supportive of appropriate and sustainable aquaculture development. In doing so, the Government of Fiji has four main objectives:

Food security – improvement of human nutrition, and increase in availability of protein at the subsistence level of the economy;
Rural development – provide an additional source of income and employment for artisanal fishers, and ease pressure on capture fisheries;
Import substitution – provide for local demand using locally produced seafood, and avoid loss of foreign exchange on imported goods;
Export earnings – bring in overseas dollars and contribute to export-led economic growth.

Current economic contribution to the nation:

FAO statistics for worldwide aquaculture production by region show that Oceania always comes last in terms of both tonnage and value (FAO 1999b). Even then, the Oceania figures are dominated by Australia and New Zealand production of pearl oyster, edible oyster, salmon, and mussels, with Pacific island aquaculture production being globally insignificant. Still, aquaculture has the potential to be regionally very significant in these smaller economies, as export earners, for import substitution (particularly to support tourist industries), and for food security.

In Fiji, accurate economic statistics on aquaculture production and value are difficult to obtain. Fiji Fisheries Division collects statistics on municipal-market sales of all fish products, and on fish imports; these get published in the Fisheries Division Annual Report series. The problem is that their database makes no distinction about the mode of production (that is, aquaculture c.f. capture fisheries). Presumably this is because, until very recently, Fiji

fish production was almost entirely from capture fisheries, however it makes identification of the aquaculture component difficult. In order to track the growth of the aquaculture sector and provide a measure of progress, Fisheries Division will need to add aquaculture to the list of other fisheries sectors (artisanal, longline, pole&line, etc) that it collects statistics for.

Similarly, estimates of the aquacultured component of fish exports were not available at the time of writing. In fact, on the value of all fish exports from Fiji, the Fisheries Division Annual Report 1997 has the following to say; "It is difficult to give exact estimate of the product due to the nature of export market (Japan, Taiwan, USA – auction market). However, estimated the export value could well above $F135 million. This contributes 5% to the nations Gross Domestic Produce" [*sic*]. Since export licences are required for fish products, it should be possible to extract this information from government statistics although, again, the mode of production may not be identifiable. It may be assumed, however, that almost all of the edible aquaculture products are sold locally, while the exports are made up of seaweed, aquarium-sized giant clams, and pearls.

With the available statistics it is possible to identify aquacultured production for the main commercial species, if they are species for which there is little capture-fishery production. For example, in 1996 Fisheries Division recorded production of 122 T of tilapia in 1997, with a value of F$366,000, and sales of aquarium-sized giant clams of F$746. In 1998 tilapia production was 242 T or F$726,000, and virtually all was disposed of locally either for subsistence or through market sales. For others, such as *ura* (prawns), the statistics collected are for more than one type (*Macrobrachium* and *Penaeus* spp. combined) and from more than one source, so a breakdown of this market is hard to determine, however aquacultured prawns are currently estimated to be worth F$500,000 per year of which almost all is sold locally. At the time of writing, *Kappaphycus* production so far in 1999 was 120 T and worth F$100,000, of which almost all was exported to Denmark. No information is available about the value of blacklip pearls from aquaculture production in Fiji.

In summary then, the aquaculture ventures that currently make money in Fiji (penaeid shrimp, tilapia, *Kappaphycus* seaweed, blacklip pearl) are currently worth about F$1.3 million per annum. This can be broken down roughly into a domestic value of F$1.2 million (shrimp, tilapia) and exports of F$100,000 (seaweed).

Aquaculture production in Fiji is therefore still very small (less than 10% of the value of all fishery exports). It can, however, be expected to increase. With a range of additional projects that may soon come on stream, Fiji could be poised for rapid growth of its aquaculture sector.

INSTITUTIONAL ARRANGEMENTS FOR AQUACULTURE

"Institutional arrangements" means the governance arrangements for aquaculture, which can exist at national governmental level, regional level, and non-governmental and private-sector level. Generally, the role of government in aquaculture is three-fold:

1. Government **regulates** aquaculture, to ensure sustainablilty;
2. Government **enables** aquaculture, by providing in legislation for necessary property rights to be acquired by private-sector investors (with procedures for conflict resolution);
3. Government **develops** aquaculture, by taking a lead in research and development.

These can be elaborated into the following potential areas where governments are typically involved:

1. Management of environmental effects of aquaculture ("regulate");
2. Protection of public health ("regulate");
3. Biosecurity and border protection ("regulate");
4. Provide efficient means for people to acquire the necessary property rights for aquaculture, through creation and allocation of aquaculture rights and through provision of efficient mechanisms for transactions with resource owners, plus conflict resolution mechanisms for allocation of scarce resources ("enable");
5. Research and development, especially pre-commercial phases, environmental impacts, environmental monitoring ("develop");
6. Human Resource Development (training) and technology transfer ("develop");
7. Provide financial incentives for aquaculture development where appropriate ("develop");
8. Legal support; legislation to empower or control all the above ("enable", "regulate");
9. National Aquaculture Planning, to provide a coordinated approach to all the above ("regulate", "enable", "develop").

Fiji Fisheries Division

The lead government agency for aquaculture in Fiji is the Fisheries Division of the Ministry of Agriculture, Fisheries, Forests and ALTA (MAFF). This department administers the Fisheries Act (Cap. 158 of the Laws of Fiji), under which Fiji fisheries waters are defined, and which provides for licencing and regulation of fisheries activity. The budget and staffing levels of the Division have remained almost constant in recent years, while the demands upon its resources have been increasing owing to the rapid expansion of commercial fisheries in Fiji (South and Veitayaki 1998).

Since 1997 the Ministry has had available to it a package of funding from Government for projects under a *Commodity Development Framework* (CDF), which is aimed at diversification of the primary sector and generation of new export products. Because of hardships in other economic sectors in Fiji (for example, sugar), there has been increasing pressure to develop marine resources. The Fisheries Division decided to redirect its activities away from its traditional service-oriented functions, to now focus only on selected commodities which can become full-fledged industries within a 3 to 4 year timeframe. The aim is to "jump-start" particular industries through government action to initiate

development projects and provide infrastructure, without waiting for donors or private-sector investment (Lagibalavu 1999, Fisheries Division Annual Report 1997).

Most of the marine commodities selected under CDF have been aquacultured commodities, for example, *Kappaphycus* seaweed and milkfish *Chanos chanos*. The aim of each CDF project was to start from the market, and work backwards to processing and production, to develop a total project package that can later be devolved to the private sector as a viable "going concern". In this way, government hopes that CDF support will overcome the "fledgling industry syndrome" that is often faced by the private sector in bridging the gap between technical success and commercial success.

To make best use of the CDF funding, a new Aquaculture group was created within the Fisheries Division, with three sub-groups; a Freshwater Programme (tilapia, *Macrobrachium* prawns, carps), a Brackishwater Programme (milkfish, penaeid shrimps), and a Mariculture Programme (giant clam, trochus, and seaweeds). A range of other new projects will also be looked at. Fisheries Division currently has 24 scientific/technical staff and 40 support staff working in aquaculture.

So far, it is fair to say that the Government of Fiji, through the Fisheries Division of MAFF, has concentrated mainly upon the "develop" role of government, especially items (5) and (6) above.

Lands & Survey Department

This department administers the Crown Lands Act (Cap. 132 of the Laws of Fiji), which includes seabed lands below high tide mark. The Act provides for grant of foreshore leases and licences, after an application process that includes consultation with traditional fishing rights owners and other affected coastal users. So far (mid-1999) only two applications for aquaculture have ever been made, and these are still being processed.

Environment Department

As part of efforts to meet international obligations toward the environment stemming from UNCED and Agenda 21, an Environment Department has been set up by Fiji Government with oversight of environmental issues and with the role of infusing an environmental dimension into the development-oriented activities of other government ministries. Various new statutory powers needed by this department are not yet a reality, because the draft Sustainable Development Bill was still awaiting a slot in Parliament's legislative programme at the time in May 2000 when Fiji's Parliament was suspended. Once law, this Bill will formalise environmental requirements for development projects such as Environmental Impact Assessment, which presently can only be implemented at a policy level under current legislation.

Fiji Trade and Investment Board (FTIB)

The FTIB facilitates foreign investment in Fiji, and provides a "one-stop shop" for overseas investors who want to establish businesses in Fiji. A single application can be made to FTIB, which will then liaise with other government departments to gain all necessary statutory

approvals (work permits, customs or finance approvals, etc) and then communicate Government's decision to the investor. This streamlines the investment process for outsiders who may be unfamiliar with the workings of government in Fiji.

The private sector

The role of the private sector in aquaculture includes:
1. Responsible and sustainable use of natural resources
2. Maximise profit, and contribute toward export-led economic growth
3. Organise into a professional association to represent their industry's interests in a coherent and sensible fashion
4. Provide employment
5. Research and development (especially pilot production scale, and market research)

Being very much a fledgling industry in Fiji, it is perhaps to be expected that the business part of the private sector has so far concentrated upon (2) and (5); maximise profit, and research & development. The extent of the private sector in Fiji has already been indicated under the earlier headings for the various aquacultured species. One important thing to note is that the private sector for aquaculture in Fiji can have two components; the business level, and the community or subsistence level. For example, tilapia farming development has mainly occurred at the community or subsistence level in Fiji, with the prime objective being food security rather than monetary gain.

Regional/international-level institutions

Fiji has available to it assistance in aquaculture under a variety of bilateral and multilateral arrangements. Bilateral assistance in fisheries and aquaculture has been provided to Fiji mainly by Government of Japan through its overseas development assistance agencies, Japan International Cooperation Agency (JICA) and Overseas Fishery Cooperation Foundation (OFCF). There has also been assistance from Government of Australia through AusAID (for example, the joint MAFF/ACIAR project on tilapia genetic improvement) and Government of New Zealand (assistance with seaweed farming development during the 1980's).

Regional multi-lateral initiatives that can support aquaculture in Fiji include the following:

FAO South Pacific Aquaculture Development Project Phase Two (SPADP-II)

Based in Suva and serving the Forum countries, this project is now at the end of its second 5-year phase and will not be extended. The aim of the project was to provide technical assistance to countries, to identify aquaculture priorities, provide information, and assist with implementation of aquaculture trials.

Secretariat for the Pacific Community (SPC)

Participating countries want to see continued regional support for aquaculture after the expiration of SPADP. Discussions are currently underway to find out whether the Secretariat for the Pacific Community (formerly South Pacific Commission) could take on a

coordination role for aquaculture under a new arrangement that involves SPC and other regional organisations. SPC has no current direct involvement in aquaculture, so must find support for a new staff position to make this possible.

ICLARM

ICLARM is an international aquaculture research institute with a South Pacific facility at Aruligo near Honiara in the Solomons. Its work has been on giant clam, beche de mer, pearl oyster and reef finfish. ICLARM's aim is to develop methodologies for target species that encompass both technical and economic aspects, to demonstrate economic viability, and hand over to Pacific island governments and private sectors a complete and workable aquaculture development package for that species. Political upheavals in Solomon islands led to the destruction of the ICLARM facilities at Aruligo, and they are now in the process of relocating to another Pacific island country.

The University of the South Pacific

Thanks to bilateral aid from JICA of Japan to the Fiji Government, a new F$25 million facility for the Marine Studies Programme was completed in 1998 at USP's Laucala Campus in Suva. A seawater tankroom is part of the new complex, and will enable staff and post-graduate research, and short-course aquaculture training, to take place in Fiji on a range of species. A new undergraduate course on Aquaculture is being developed for the BSc (Biology) and BSc (Marine Science) degree programmes, and will be offered in 2001.

The University of the South Pacific's Institute of Marine Resources (the applied research and consultancy arm of the Marine Studies Programme) was relocated to the Solomon Islands, and a Director was appointed who has a strong background in aquaculture. Phase I of IMR was officially opened in May 1999 on land next door to the ICLARM facility at Aruligo, and is now also looking for a new home.

Forum Secretariat

The Forum Secretariat, based in Suva, administers various aid budgets on a regional basis. A focus of recent assistance has been private sector development, which of course can include aquaculture development. Their various sources of funding can be used to obtain technical assistance, consultants, training and marketing opportunities for applicants from the private sector. The coordinator of the Council of Regional Organisations in the Pacific's (CROP's) Marine Sector Working Group is also based within the Forum Secretariat. This working group has the function of ensuring that the activities of various CROP organisations' activities in the marine sector are integrated and avoid overlaps.

Regional coordination of aquaculture

It was proposed that, in the post-SPADP era, SPC, ICLARM, USP and SPC member countries should work out a Regional Aquaculture Strategy to coordinate the roles of the various regional institutions. The various institutions have complementary roles. ICLARM, now re-named Worldfish Centre, can undertake long-term research and development of new species and technologies from base-line research through to marketing.

USP can carry out short-term research on specific topics, and focus on capacity-building (education and training of undergraduate students, regional governmental staff and private sector personel in aquaculture). SPC and member governments can implement aquaculture development projects at the "grassroots" level and provide assistance to the private sector. Such coordination would help to provide a better institutional environment for development of aquaculture industries in the region. The Strategy is being coordinated by an SPC aquaculture project funded by AUSAID. Fiji, as an SPC country, is one beneficiary of this regional strategy.

AQUACULTURE PROPERTY RIGHTS IN FIJI

A crucial part of private sector involvement in aquaculture development is obtaining secure property rights, to provide the basis for investment. Secure property rights are an important part of business confidence in any sector of the economy. As mentioned earlier, aquaculture requires rights to harvest fish, rights to occupy space, and authority for any environmental impacts. Government needs to ensure that a statutory mechanism is in place for allocation of property rights for aquaculture in a way that fosters private-sector (both commercial and traditional) investment yet safeguards the public interest in marine resources.

Sources of aquaculture property rights for the coastal marine environment are not very clear in Fiji at present. Fiji, in common with all other Pacific island developing countries, has no aquaculture legislation that provides explicitly for it to be either enabled or regulated. It is necessary to either acquire such rights in the marine environment under generic legislation, or else follow the strategy of obtaining freehold or leasehold land and concentrate upon land-based aquaculture. So far, commercially successful private-sector involvement in aquaculture in Fiji has been almost entirely land-based. It is timely that we now discuss what, if any, generic institutional arrangements may enable aquaculture in the marine environment.

Bearing in mind that a marine aquaculture right is essentially a right to subdivide a fishery area and establish a more exclusive claim over the fish in that area, it is useful to examine the situation for **ownership of fishing rights** for inshore areas of in Fiji. Exclusivity to protect farmed stock can, however, be obtained in one of two ways; either by an exclusive fishing right (where other people's access to the farm area is still allowed but they are banned from fishing), or by an exclusive occupation right (by obtaining a lease over the seabed of the farm area, so other people are banned from entering the area). It is therefore also useful to also examine **ownership of the seabed** in Fiji.

Ownership of rights to harvest fish in Fiji

Customary fishing rights in Fiji were traditionally owned from land out to the outer edge of barrier reefs, enclosing the reef edge, reef flat, and lagoon area bounded by the reef. The situation today is that traditional fishing rights areas (*qoliqoli*) are being codified by the Native Lands and Fisheries Commission, through demarcation of boundaries and negotiations to resolve any disputes. Four hundred and eleven such *qoliqoli* have been surveyed and are now listed in the Register of Fijian Customary Fishing Rights. Rights to harvest fish in the open-sea areas within Fiji's Exclusive Economic Zone outside of the reef, which with advancing technology may someday be of interest for aquaculture, are vested with the state

Ownership of the seabed in Fiji

The situation of seabed ownership has recently been reviewed by South and Veitayaki (1998). In brief, under the 1874 Deed of Cession traditional owners lost any ownership of fishing rights and ownership of seabed lands to the British Crown. Usage rights for fishing were subsequently returned to traditional owners, but not ownership of seabed lands below high tide mark which remained vested with the state. Fiji since Cession has thus followed the British system of marine tenure where rights to land, rights to water, and rights to harvest fish are divisible from each other in terms of ownership. This is in contrast to the traditional Pacific island view that the sea is an integral part of the land.

Theoretically then, there is a right of public access to coastal lands and waters below high tide mark, while more permanent and enforceable property rights can be obtained by applying for a foreshore lease or licence from Lands Department. In practice though, traditional rights extend to more than just fishing rights in the minds of many, and this has been a source of misunderstanding and, in some cases, conflict. One example has been the famous Tavarua Cloudbreak surf spot in Fiji, where surf tour parties who followed the British system of public access encountered opposition and even violence from villagers who viewed it as a customary right to control access to the surf spot and receive cash payments for grant of permission. Such misunderstandings can only have an adverse effect upon investor confidence in marine tourism ventures, or any other business like aquaculture for which a marine location is essential.

Possible sources of property rights for aquaculture

South and Veitayaki (1998) have examined these ownership issues mainly from the standpoint of fostering customary marine tenure for fisheries. They did not explicitly address the issue of aquaculture rights, but these are implicitly a part of fishing rights so the discussion in their paper has implications for aquaculture. We will now analyse the existing marine tenure arrangements in Fiji (described in South and Veitayaki 1998), to find possible sources of (i) a right to take fish for an aquaculture activity, that provides a "shield" against any statutory prohibition, (ii) a right to *exclusively* take fish in the farm area, a "sword" that protects farmed fish from being taken by others, and (iii) a right to occupy seabed lands more or less exclusively, as a "sword" to exclude trespassers from entering the area.

A right to harvest fish for aquaculture

The starting point is the Fisheries Act, which prohibits the taking of fish in Fijian waters by way of trade, business, or other commercial purposes without a licence. There is no statutory exemption for aquaculture (be it harvesting, or spat-collecting), and there is no other source of authorisation to take fish except under a fishing licence. Fijian waters are defined as all internal waters, territorial waters, archipelagic waters, and waters of the Exclusive Economic Zone. Internal waters includes freshwater ponds, or even the water in somebody's goldfish bowl. Technically, all aquaculture in Fiji, whether land-based or marine, requires the authorisation of a fishing licence before fish can be "taken". This is irrespective of the ownership of the fish, about which the Fisheries Act makes no distinction. The prohibition on taking fish without a licence also applies to aquaculture by traditional fishing rights owners, since they too are required to hold a licence if the fish are being taken for commercial purposes.

Nobody seems to be very worried about the fact that all aquaculturists in Fiji are technically committing offences against the Fisheries Act, presumably because Fisheries Division has not (in practical terms, quite reasonably) followed a policy of mounting any prosecutions against aquaculture operators. This is fine when aquaculture is still in its infancy. But when aquaculture achieves the higher economic profile that is being hoped for, then the position of aquaculturists in terms of the Fisheries Act will need to be validated. No one will want to make million-dollar investments knowing that, technically, they are at the mercy of a benevolent bureaucracy. And if anyone objecting to aquaculture development were ever to lay a complaint, then Fisheries Division would be forced to act according to the law as written.

There are two options to validate the position of people who want to "take" fish from an aquaculture operation. The first is to create for aquaculture a statutory exemption from the prohibition on taking fish without a licence (for example, provide for a separate aquaculture licence). The problem with this is that aquaculture would need to be defined in a way that makes it different from fishing, and we return you to the discussion that opened this chapter for reasons why this option should not be preferred. One of the authors (TDP) has had experience of this option under New Zealand fisheries law, and did not find that it offered a robust or lasting solution, especially where aquaculture for re-stocking of fisheries is being contemplated.

The second option is to expand the scope of a fishing licence by amending the Fisheries Act so that these licences can be used to cover aquaculture operations as well. The type of right being granted is the same, the only difference is that the licence conditions covering environmental or other matters need to be flexible enough so that aquaculture will not be unduly penalised compared to the more-strict compliance regime usually attached to capture fishing. We recommend this second option as a legislative "fix" for this issue.

Currently, anybody who wants to take fish for commercial gain from a traditional fishing rights area (including members of traditional fishing rights owning groups) must apply to the Fisheries Division for a fishing licence. This may be granted after consultation with, and a favourable response from, the traditional fishing right owners for the area. Grant of a fishing licence will make the harvest of fish from a marine farm "legal", but such a right will not be exclusive; it will be shared with all others who hold fishing rights in the area. They would all be within their rights in helping themselves to farmed fish. There is currently no mechanism to obtain an exclusive fishing licence for an area, except by negotiation and trade with all others who hold rights to the area to get them to stop fishing. It is not expected that this mechanism will be practicable, given the diffuse nature and large number of individual stakeholders in Fiji inshore fisheries.

To summarise so far; relatively simple amendments to current fisheries law in Fiji could make it possible for aquaculturists to acquire a fishing right that acts as a "shield" against statutory prohibition. However it would still not be an *exclusive* fishing right, that acts as a "sword" to defend farmed fish against others.

A right to occupy space, and protect aquacultured fish

An aquaculture operation often also needs to occupy space in the marine environment, and lease arrangements for that space can provide for the occupation to be exclusive so that farmed fish may be legally protected from molestation by "trespassers". A right to occupy (more or less exclusively) seabed lands may be obtained by applying to the Lands Department

for a foreshore lease or licence under the Crown Lands Act, which may be granted after consultation with traditional fishing rights owners (if the application falls within a traditional fishing rights area) and the public at large. If all goes smoothly, the application process takes about one year. At the time of writing, only two applications have ever been made for a lease or licence for aquaculture in Fiji. These applications are still being processed. One is an application for a foreshore licence covering an area of 20 ha in Vanua Levu, with the application made by Pearls Fiji Ltd (the only commercial pearl farm, and currently the sole private marine farm, in Fiji). Their purpose for making application was to gain an exclusive area where they could prevent boats or people entering the farm, to avoid damage to structures or theft of farmed stock. A second application has been received for a coral reef area in the Mamanuca Group, to provide legal protection for re-stocking of giant clams, beche-de-mer, pearl oysters, and other sedentary species. These applications are setting the precedent for acquisition of enforceable rights over a marine farm areas in Fiji.

The property rights contained in a lease are usually quite strong, far stronger than are needed for most aquaculture operations. It means that lease applications are only likely to be successful if the farm area is very small, or if the locality is very isolated. The application process itself is not an easy one, and would most likely involve payment of compensation to traditional fishing rights owners. In general, strong property rights are costly to obtain. What is really needed for most aquaculture operations is a less draconian property right, that gives exclusivity over the farmed fish species, but which continues to allow public access and which leaves intact any existing fishing rights for other species. An aquaculturist is interested in the farmed fish, not the land. Provided the fish are left alone and farm property is not damaged (fisheries legislation can provide separate offences for these), trespass rights should not be necessary. Currently however, the long, tortuous, potentially costly, and still untested avenue of acquiring a foreshore lease or licence is the only way to gain exclusive rights over farmed fish in Fiji that are enforceable in law.

Regarding the third component of aquaculture property rights, environmental restrictions are still quite minimal. Fiji as yet has no statutory requirements for Environmental Impact Assessment (EIA is currently implemented at the policy level under various Acts) or water quality standards. Major aquaculture projects can expect to have to carry out an EIA. It will be difficult for an investor to tell in advance what environmental management regime will be attached to their project, as this will most likely be implemented through licence or lease conditions on a case-by-case basis, rather than through generic statutes or regulations.

The current legislative situation will make it difficult to reach the full potential of aquaculture in Fiji. Aquaculture appears not to have been contemplated at all by the drafters of fisheries or marine spaces legislation. Rights to harvest farmed fish are not provided for in legislation except as fishing licences. Rights to protect farmed fish from harvest by others can only be provided through seabed leases, which are much stronger property rights than are actually needed for many forms of aquaculture. For marine aquaculture to reach its potential in Fiji, the situation regarding property rights and environmental management regimes needs to be clarified and improved through amendments to the relevant pieces of legislation.

The position of traditional fishing rights owners

As it happens, traditional fishing rights owners have not themselves been entirely happy with the present legal situation either. Over the years, mention has been made in various meetings of provincial councils and the Great Council of Chiefs (GCC) that the ownership of marine

spaces and resources needs to be clarified, preferably by return of ownership of seabed lands within fishing rights areas to traditional owners (South and Veitayaki 1998). Additionally, fishing rights owners in some places are frustrated that they themselves cannot establish more exclusive and enforceable harvesting rights over areas that they want to use for coral aquaculture or giant clam re-stocking, except through the mechanism of Marine Protected Areas whose primary aim is the cessation of all fish harvesting (Muaikaba Fishing Cooperative, pers. comm.). Provision in legislation of a more exclusive kind of fishing right to cater for aquaculture would therefore benefit both traditional fishing rights owners with aquaculture aspirations, and aquaculture investors from the commercial part of the private sector.

The issue of seabed lands was raised during the two constitutional reviews that took place in Fiji during 1990 and 1997. Not long before the 1999 election, Cabinet decided that legislation should be drafted to return to traditional fishing rights owners the ownership of seabed lands within their demarcated fishing rights areas (Fiji Times, 28 April 1999). The outcome of the 1999 election, however, was a change of government in Fiji, and the new Coalition government did not make any pronouncements on this issue.

Following the attempted coup of 19 May 2000 a new interim Government was established in Fiji, which promulgated a "Blueprint for the Protection of Fijian & Rotuman Rights and Interests, and the Advancement of their Development" (Daily Post, 14 July 2000). A list of proposed legislative action by decree includes the following item - *"Ownership rights to Customary Qoliqoli – The conferment of ownership rights, similar to customary ownership of land, on all traditional qoliqoli, as requested by the GCC and the NLTB. [This will take some time as survey and demarcation of boundaries by the Native lands and Fisheries Commission need to be completed. Appropriate safeguards will be included in the legislation on the right of public access and the protection of the interests of investors.]"*

The legality of the interim Government was successfully challenged in the now-famous Chandrika Prasad case, and Government's February 2001 appeal of that High Court ruling was lost. There is now uncertainty about the validity of interim Government decisions such as the Blueprint and any decrees stemming from it, and uncertainty about the nature of any future government. Issues relating to lease of communal lands are at the core of these political developments, and a wide divergence of views is apparent.

Accordingly, it is still open to speculation how any new arrangements for lease-hold or other "renting" arrangements of seabed for aquaculture might operate.

One option is to follow the existing model administered by the Native Land Trust Board for agricultural land leases. Under this system, investors seeking aquaculture sites would presumably apply to the Board, who would then negotiate with land owners, fix rentals and other conditions, and collect lease money for payment to landowners. The new situation regarding compensation for any loss of fishing rights would also need to be made clear.

Alternatively, Government may wish to take a fresh approach to marine tenure, rather than transfer existing land tenure problems into the marine environment. It must also be remembered that areas outside of *qoliqoli* remain vested with the state, so a dual system (with dual administrations within government) will need to be operated in any case.

An opportunity for a legislative "fix" for aquaculture

Because Government's decision in the Blueprint would treat traditional fishing rights holders as "owners" of the coastal seabed rather than as just one of several groups of "users", the proposed hand-over has the potential to clarify the marine tenure situation and provide more certainty and security for all parties concerned. If aquaculture policy can be included into the same legislative agenda and be "fixed up" at the same time, it could also open the way to real expansion of commercial marine aquaculture in Fiji on a sound legal footing.

In other words, there is a legislative opportunity to design a seabed tenure system that provides in statute for at least some of the property rights needed for aquaculture, in a way that treats it generically along with other marine activities and in a way that avoids having to legally define "aquaculture", if government follows through with the proposed transfer of seabed ownership within *qoliqoli*.

For this to become reality, Fisheries Division officials and private-sector aquaculturists will need to ensure that they have input to the policy-making process for implementation of Government's seabed lands decisions. It must be remembered that, as yet, there has been no explicit mention of aquaculture in any of the discussion about return of ownership of seabed lands. Without specialist policy input from the aquaculture sector both inside and outside government, the opportunity may be missed.

It would be timely to also review other legislative requirements for aquaculture, to find out if any aspects of property-rights allocation or environmental management need to be provided specifically for the aquaculture sector. Firstly, all aquaculturists need their position to be validated in terms of the statutory prohibition in the Fisheries Act on taking of fish without a licence. The fishing licence provisions of that Act could be amended to make them "aquaculture-friendly" and, if necessary, to provide for allocation of more exclusive fishing rights in small areas for aquaculture so that the need for seabed leases can be avoided altogether. Secondly, there may be particular environmental issues (such as powers to control the spread of fish diseases) which need special-purpose aquaculture legislation, rather than just be dealt with generically. This could be done by amending the Fisheries Act to include a new Part on Management of Aquaculture.

CONCLUSION

Aquaculture has come a long way in Fiji since the 1970's, and Fiji now leads the Pacific island developing countries in terms of aquaculture development and diversification. The breakthrough was tilapia farming, which was the first form of aquaculture to make the leap from technical success to economic success and really take root in Fiji's private sector (at both commercial and subsistence levels). *Kappaphycus* seaweed farming looks set to follow, after an earlier false start. Saltwater shrimp farming continues to be profitable for those involved, though suffers constraints to expansion. Freshwater prawn farming now looks promising. A range of other projects have enjoyed technical success and work is continuing to bridge the gap into economic success for those projects too. Fiji can be regarded as being at a consolidation and diversification phase in its development of an aquaculture industry.

Efforts by Fisheries Division of MAFF have so far mainly focused upon the **development** aspect (especially research and training) of governmental roles in aquaculture. In the longer term, it is desirable that the main initiatives in commercially-oriented aquaculture development come from the private sector (though government always has a role in pre-commercial research & development), while Fisheries Division widens its focus to include the other two main roles for government; to **enable** aquaculture (for example, provide in legislation for aquaculture licensing) and **regulate** aquaculture (provide for environmental management).

Steps that still need to be taken to further strengthen institutional arrangements for aquaculture in Fiji, to provide for its consolidation and expansion, include:

- Ensure that any new seabed tenure system under an amended Crown Lands Act can also smoothly provide for allocation of space-occupation and trespass rights over seabed in a way that is appropriate for all sectoral interests in aquaculture;
- Amend the Fisheries Act to validate the position of aquaculture operators in terms of the statutory prohibition in that Act on taking of fish without a licence;
- Amend the Fisheries Act to include a new Part on Management of Aquaculture, to provide for the creation through regulation or licence conditions of a management regime for the environmental aspects of aquaculture;
- Add aquaculture to the list of other fisheries sectors (artisanal, longline, pole&line, etc) that Government collects statistics for;
- Encourage the Aquaculture Industry Association to represent private-sector aquaculture interests and contribute to aquaculture policy development;
- Identify specific training needs for aquaculture in the public-sector, private-sector, and in the community, and find ways to meet these training needs to strengthen sustainable aquaculture development capacity.

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