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LESSONS FROM PAST AND CURRENT AQUACULTURE INITIATIVES IN SELECTED PACIFIC ISLAND COUNTRIES

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Cover photos: Counterclockwise from top left — a coral nursery in Solomon Is, giant clams in Kiribati, a harvest of South Sea pearls in Savu Savu, Fiji (courtesy of J.Hunter Pearls), and tilapia for cage culture in Vanuatu

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Building on Lessons: Areas for Assistance

Regional Synthesis of the Lessons Learned from
Past and Current Aquaculture Initiatives in Selected PICs

TCP/RAS/3301

SUMMARY

This report is a synthesis of the reviews of aquaculture development status and experiences of eight Pacific Island Countries (PICs). Seven PICs were covered during May-September 2010; the eighth was the subject of a separate project carried out in July 2009. The country reviews cover recent and current developments, supplemented by a comprehensive historical review of aquaculture in the Pacific conducted in 1984 by the Hawaiian-based Pacific Islands Development Program (PIDP).

The remit of this project (TCP/RAS/3301) was to identify areas for technical assistance that would further promote aquaculture development. This was accomplished by identifying issues in sector governance relating to the success of aquaculture enterprises and drawing lessons on what factors contributed to success and what led to the abandonment or termination of a farming enterprise and why. The screens used for success were biological feasibility, technical feasibility, economic viability and social acceptability. Sustainability would be the ultimate screen but no specific criteria were set up for this, and could only be inferred from the continued operation of an enterprise. Thus, the core of the lessons learned comprises the factors that enable economic viability of the farming of a species. This screening mechanism is explained in the report.

The context for technical feasibility and economic viability is sector governance. In this connection, the various mechanisms of governance and its enabling elements that include capacity building and institutional development and linkages were reviewed and assessed as to how and what extent these have specifically influenced technical and economic success, and the management of aquaculture development. The assessments appear in detail in the country reviews (Section 2 of this report) and are categorized into strategic, management and technical lessons. The recommendations necessarily address the same issues associated with the governance mechanisms (command and control, market-based, voluntary, and social norms and traditions) and those associated with the weaknesses of the enabling mechanisms (including manpower development, institutional capacity building and linkages, stakeholder participation, and knowledge development and sharing). A general recommendation is to catalyse these through a regional cooperative arrangement such as a network based on technical cooperation, with its formation and initial stage of operation facilitated by a regional technical assistance.

The informal meeting on aquaculture in the Pacific, held in conjunction with the recent Global Aquaculture Conference 2010 in September in Thailand, contributed to the development of this synthesis. The provisional findings of this project were incorporated in a briefing note for the meeting. Information and professional views that enriched the findings were provided by the presentations of FAO SAP and SPC and country statements of the delegates from five PICs. The discussions gave a more rounded perspective of the issues raised in the briefing note. Strategic actions to assist the region were recommended. The Report of the Meeting is part of this synthesis and appears as Annex 4. In addition, an article on the results of the informal meeting appears in the FAO Aquaculture Newsletter no. 46 (or FAN-46).

I. INTRODUCTION

Previous assessments of fisheries development in the Pacific region have noted the decreasing inshore fishery resources, which supply much of the fish in the diets of the people of the Pacific Island nations. In their meeting on 20-22 May 2009, in Niue when the world was barely out of a financial, fuel and food crisis, the agriculture ministers of several Pacific Island Countries (PICs) stressed the urgency of assuring the food security of the peoples of the Pacific region. They then requested FAO to provide

the PIC governments and their private sectors clear guidelines for enhancing the role of small scale fishery and aquaculture as a sustainable supplier of food.[1]

Taking this request on board, the FAO Sub-regional Office of the Pacific Islands (SAP) formulated the regional project TCP/RAS/3301 (regional overview of aquaculture development in the Pacific). Its main purpose was to review the past and present aquaculture development initiatives in selected PICs, to learn important lessons from them, that could provide the guidelines governments and development assistance agencies needed. The initiatives reviewed included national development programmes, pilot projects and farming enterprises. The technically oriented review was complemented by a review of national policy and legal framework, as well as strategies and plans for aquaculture development. The recommendations address food security, income and improvement of livelihoods that are based on aquaculture.

1. **Objectives**

The project objectives were to review national fisheries policies and legal frameworks, management, development and strategic plans, and past and current aquaculture projects and their results; assess broadly the economic impact of aquaculture development in countries; and document lessons learned from these past and current aquaculture development initiatives. The Terms of Reference of the project is Annex 1.

2. **Coverage**

This report covers eight countries, two in the North Pacific and six in the South Pacific regions. Seven were reviewed under the regional project TCP/RAS/3301 and visited between May and September 2010. The eighth, Cook Islands, was the subject of a separate mission under the TCP/CKI/3201 carried out on 4-23 July 2009[2].

3. **Process**

The primary information was obtained with a brief questionnaire (Annex 2) sent by the FAO SAP to the concerned government agency, and by personal interviews or group meetings with policy makers, managers, officers, and technical workers of government, personnel of academic institutions, NGOs and private sector enterprises, project and farm managers and technicians, farmers, women in aquaculture business projects, the Secretariat of the Pacific Community (SPC) and the FAO SAP officers; and visits to projects, farms, government R&D centres and hatcheries. Institutions visited included fishery and regulatory agencies, schools, private enterprises, and fishery industry associations, the FAO SAP and the SPC. Secondary sources of information included regional, national and commodity reports and reviews, policy statements and acts, and regional and national aquaculture strategies and plans.

This mission visited the following PICS on these dates: Palau and Marshall Islands on 5-18 May; Kiribati and Vanuatu with a short visit to SPC Headquarters in Noumea, New Caledonia, on 18 June-8 July, and Fiji, Tonga and Samoa on 17 August-3 September 2010. After each visit, the draft country reports were submitted to FAO SAP for review.

The provisional findings of the mission were incorporated in a Note[3] prepared for the informal meeting on aquaculture in the Pacific hosted by FAO FIRA (Aquaculture Service of the Fisheries and Aquaculture Department) and NACA (Intergovernmental Organization of the Network of Aquaculture Centres in Asia-Pacific) on 23 September 2010 in Phuket, Thailand, in conjunction

[1]Communiqué of the Eighth Meeting of the FAO South West Pacific Ministers for Agriculture, Alofi, Niue, 20-22 May 2009. 6p. www.foodsecurepacific.org/.../Communique%208%20SWPM%20FAO.pdf

[2]The seven PICs are, in the order of the mission's visit, Palau, Marshall Islands, Kiribati, Vanuatu, Fiji, Tonga and Samoa.

[3]FAO SAP and SPC. 2010. Building on Progress: An Evening on Pacific Aquaculture. Briefing note prepared for the informal meeting on aquaculture development in the Pacific, Phuket, Thailand, 23 Sept. 2010. 16pp.

with the Global Conference on Aquaculture 2010. The report of the meeting was circulated to the participants, PIC governments, and institutions and organizations providing donor and technical assistance in fisheries to PICs. This synthesis was developed after the informal meeting and incorporates the salient recommendations of that meeting. The Note is a succinct volume and is an informative complement to this report. It is an attachment to Annex 4.

The country reports earlier submitted to FAO SAP were abridged and constitute Section 2 of this Report. It includes a short version of the report of a mission conducted by the same consultant in Cook Islands on 4-23 July 2009. These appear in this order: Palau, Marshall Islands, Kiribati, Vanuatu, Fiji, Tonga, Samoa and Cook Islands.

II. LESSONS

The lessons drawn from the review of national initiatives fall into two activities with crucial linkages: (a) establishing the feasibilities of culture species and their production systems and (b) managing the sector. Three general findings are instructive: (1) most of the culture species proved to be technically feasible but failed to fulfil commercial expectations, (2) the development strategies for the sector were intensely focused, and at times repetitive on the research phase so that resources soon became insufficient for scaling up results into commercial application, or attention was diverted from the other essential requirements of economic viability particularly market access, market development, and competitiveness, and (3) investment risks - other than the natural - were ill-defined or insufficiently addressed (FAO SAP and SPC, 2010).[4]

The enactment of a national policy on aquaculture development and the formulation of national strategies and plans to implement the policies are fairly recent developments in most of the countries, except Tonga which had formulated one in 2003. Some countries have a more specific commodity development plan. Apart from their value as a guide for managing the development of the sector, these give encouraging signals for private sector investment; that their investment would be secure and protected; the rules are clear, predictable and can be relied on for long-term planning. The commodity action plans go beyond production to include product transformation, market studies and market development. The specific actions however are not clearly stated in the plans, although these are usually provided in the annual plan and budget of the fishery and marine resources department.

A critical gap is the lack of specific policy support for the development of private sector investments in the support services, e.g. seed and feed production and supply, credit and insurance, transport and handling, processing, local marketing and international trading. These have mostly been initiated by government, which is an important role, but apart from a few cases, government continues to perform these functions which could stunt private sector growth in these areas. Moreover, it can be an inefficient allocation of national resources.

This section presents and describes the lessons in two ways: the first part are the lessons that apply broadly to the region, the second are specific lessons drawn from projects and farms.

1. Feasibility of species and systems

The lessons from past and current aquaculture initiatives are based on the analysis of the important species and their farming systems. An analytical framework identifies and characterizes the feasibility issues of farming the species, namely, biological, technical, economic and social. This analytical framework is usually applied to the screening of a potential species and its farming system before it is recommended for pilot test or trial in a wider domain, or adoption by farmers. It was applied in this study to determine the production (as well as post production and marketing) issues on the aquaculture of a species. Each country report contains the analysis. The logic of this scheme is explained in Annex 3.

[4]The Note describes 12 cases that briefly describe the factors that contributed to the success of a number of trials and commercial initiatives, and 10 cases that illustrate the constraints to biological and technical feasibility, economic viability and social acceptability that contributed to failures.

a. *Biological feasibility*

Briefly, the screening question for biological feasibility is "Will the species survive, reproduce or grow in a given physical, natural and biological environment under which it is to be cultured?" The table below illustrates the various constraints to biological feasibility, their effects on the aquaculture trials and how these were addressed.

Biological/natural constraints	Cases (Species, Country)	Impacts on project's biological feasibility	Action taken
1. Water quality	1.1 Milkfish in Kiribati 1.2 Pearl oyster in Cook Islands 1.3 Pearl oyster hatchery in Marshall Islands	1.1.1 Low feed conversion 1.2.1 Vibrio pathogen proliferated 1.3.1 Poor hatching percentage and survival	▪ Water replenishment ▪ Reduction of density of farms and intensity of stocking ▪ Alternative source of water tapped
2. Water supply reliability (drought)	2.1 Freshwater prawn in Cook Islands	2.1.1 Stock wiped out	▪ None: Farming not resumed
3. Presence of species that are a nuisance, pest or predator	3.1 Milkfish in ponds in Kiribati 3.2 Tilapia (O. niloticus) culture in Samoa, Fiji, Vanuatu 3.3 Seaweeds in Marshall Islands	3.1.1 Slow growth from competition 3.2.1 ditto 3.3.1 Seaweed seedlings could not flourish	▪ Repeated and extended pond drying and use of chemicals with no success ▪ Cage culture in Vanuatu (successful) ▪ Seaweed culture abandoned
4. Harmful blooms i.e. ciguatera	4.1 Reef fish capture in Cook Islands	4.1.1 Adverse impact on tourist industry	▪ Monitoring and water analysis for ciguatera warning system
5. Degraded environment	5.1 Tilapia cage culture in Vanuatu 5.2. Milkfish in ponds in Palau	5.1.1 Farm is successful and became profitable 5.2.1 Degraded mangrove (from tampering of water circulation) was developed for aquaculture	▪ Government permitted private enterprise to set up cage farming ▪ State government recruited a technical group from the Philippines to develop degraded area into milkfish pond system
6. Presence of pathogen	6.1 Pearl oysters in Cook Islands	6.1.1 Vibrio proliferated because of the density of farming in the lagoons and disease infected the oysters; Many farms closed down	▪ Better management practice adopted, health management was included as an important management element
7. High water salinity	7.1 Milkfish in ponds in Fiji	7.1.1 Stunted growth, cannot produce natural (lab-lab or plankton mat) food	▪ At time of mission, no remedial step was being taken by the farm technicians; Fertilization was ineffective with high water salinity
8. Acid soils	8.1 Milkfish in ponds in Fiji 8.2 Milkfish in ponds in Kiribati	8.1.1 Stunted growth 8.2.1 Very low yields	▪ Lime applied ▪ Liming and chicken manure from farm's chicken enterprise applied
9. Range of natural habitat	9.1 Milkfish trial in Southern Cook Islands	9.1.1 Could not be sustained for lack of seed	▪ Broodstock development as well as importation planned but with no follow up action due to high cost of transport

10. Species available	10.1 Siganid in Southern Cook Islands	10.1.1 Species is slow growing; would have taken 18 months with good feeding to grow a crop to market size	▪ Trial abandoned
11. Cyclones	11.1 Pearl oyster in Fiji 11.2 Green mussels and seaweed in Samoa	11.1.1. Collection gears and growing oysters destroyed 11.2.1 Mussel and seaweeds washed away 11.2.2 Growing area for mussel silted up	▪ Rehabilitation done; on shore working facilities relocated on land ▪ Alternative site for mussel identified but no trial was resumed ▪ Seaweed culture abandoned

Summary:

- The mix of biological constraints include natural hazards, presence of predators, pests and nuisance species, unavailability of species, adverse conditions such as high salinity and acid soils. Pollution of lagoons is an increasing threat.
- Natural hazards - cyclones, floods and drought - are noted to be increasing in frequency and intensity which have tended to set back progress; some trials were abandoned after a severe event. This represents a suite of risk management strategies ranging from risk reduction such as early warning systems and reliable forecasts, to risk impact mitigation such as diversification of livelihoods and insurance, and risk impact alleviation such as damage compensation by government, relief, recovery and rehabilitation, all of which need resources and technical capacity to execute.
- The *mossambique* tilapia has become a constraint to pond culture. Cage culture of the *Nile* tilapia as in Vanuatu obviates this problem but cage culture cannot be done in brackish water pond culture of milkfish, as in Fiji and Kiribati where ponds are shallow and depend on tidal action. Pen culture, which is suitable for shallow waters, would add to costs. Cage culture of these shallow ponds is not feasible. The tilapia infestation in Kiribati has been a very difficult problem to tackle.
- Seawater acidification and warming of the waters from climate change have a potentially grave effect on pearl, marine shrimp, giant clam, trochus and green snail culture, and corals, all important sources of income of several PICs.

b. *Technical feasibility*

The question that has to be answered to establish technical feasibility is: Has the farmer the ability and the means to farm the species to an acceptable yield level and - if market oriented - sell the farm product, with a given resource structure ?

Technical constraints	Cases (Species, Country)	Impacts on project's technical feasibility	Action taken
1. Broodstock -quality is generally low	1.1 Tilapia in Fiji and Samoa 1.2 Freshwater prawn in Fiji	1.1.1 Low quality seed, low yields 1.1.2 Slow growth of prawns	▪ Broodstock improvement in Fiji; importation of better *Nile* tilapia broodstock in Samoa ▪ Importation and performance tests of various *Macrobrachium* species
2. Seed supply and quality can be unreliable	2.1 Tilapia in Fiji, Samoa and Vanuatu 2.2. Freshwater prawn culture in Fiji 2.3. Milkfish in Palau	2.1.1 Poor yields 2.2.1 Higher production costs 2.3.1 In Fiji and Samoa, some farms cease operation.	▪ Fiji and Samoa provide seed to farmers. ▪ Vanuatu farm imports all-male seed from Thailand ▪ Palau farms import seed from Taiwan and Indonesia; broodstock development initiated

3. Feed–low quality, unreliable supply, high cost	3.1 Tilapia and freshwater prawn culture in Fiji	3.1.1 Poor growth, farmers complain, some stop farming	▪ Government research station testing feed formulations and feeding regime for performance; provide feed to farmers for free
4. Lack of credit for aquaculture	4.1. All countries	4.1.1 No or slow growth in private commercial investment apart from the aquarium species (giant clam, corals and live rock), and the pearl enterprises which which have their own sources of capital as well as mother companies	▪ No government action reported; Fiji's agricultural development bank had previously loaned to a failed ▪ Shrimp enterprise
5. No insurance scheme for aquaculture	5.1. All countries	5.1.1 As there is no insurance scheme, the impact is difficult to assess.	▪ No discussions or plans reported or known. ▪ Only farm structures and facilities are insured in Vanuatu, no stock
6. Poorly developed domestic market for the small-scale farmers	6.1. Fiji, Samoa	6.1.1. Small farmers far from a local market cannot sell surplus; Roadside selling is common in Fiji and product quality can deteriorate fast	▪ Fiji's survey of farms has highlighted this issue; For prawn, buyers go around to purchase at farm gate
7. Hatchery and seeding techniques for sea cucumber	7.1. Palau, Kiribati, Tonga	7.1.1. Palau needs trained local technicians for hatchery production 7.1.2. Kiribati hatchery initiative constrained by lack of broodstock; Stock enhancement is constrained by lack of technical knowledge on site biological parameters and stock management	▪ Korean technician doing seed production in BMR hatchery as a business ▪ Sourcing of broodstock on going; on site management, the issue has been raised but no follow up action so far carried out

Summary:

- Pilot trials and initial farming on a commercial scale of many of the species indicated their technical feasibility. Apart from a handful, many failed to attain or sustain economic viability. Repeated impacts of cyclones, floods and droughts have severely set back progress. More importantly, the small local market has limited scope for its expansion. It has low competitiveness in the export market and also in the domestic because of cheaper imports or substitutes.
- Seed quality and reliability of supply (of finfish and crustaceans) remain to be constraints although steps have been made to improve them with broodstock improvement. This is not much of a

constraint with giant clams and even trochus because the breeding and hatchery technology for these species and the skills for carrying hatchery work have been much improved over the years. Sea cucumber seed production for stock enhancement has been going on in Palau, Kiribati and Tonga. In Palau, a private technician/businessman from Korea is conducting sea cucumber seed production in one section allocated for him at the Bureau of Marine Resources hatchery facility. In Kiribati, the problem is finding a suitable site and lack of technical knowledge of stocking and management of seeded sea cucumbers.

- The problem of feed for finfish and crustaceans is persistent and prevalent. Commercial feeds are mostly imported, thus expensive and producing them locally would still be costly as some ingredients have to be imported. It is like a chicken-and-egg conundrum to argue for privatisation of services such as feed and seed supply when there is not much scope for economy of scale because local demand for the input is low, because the sector is small, because the local market is limited. Governments meanwhile are formulating feed and supplying it to farmers often for free, as in Fiji and Samoa.

c. *Economic viability*

The question to establish economic viability is "Does it pay to produce the species ?".

Economic Constraints	Cases (species, Country)	Impacts on project viability	Action taken
1. High cost of inputs	1.1 Mozuku in Tonga	1.1.1High cost of energy for refrigeration makes product even less competitive in Japanese market	▪ None; mozuku farming has been discontinued
	1.2 Cage culture of tilapia in Vanuatu	1.2.1. Seed imported from Thailand	▪ Tilapia farm reduces other cost items by mechanizing as much as possible and producing its own farm made feed
	1.3 Cost of feed and seed in Fiji and Samoa	1.3 Feed provided by Government	1.3 Some trails on farm made feed in Fiji
2. Low competitiveness in export market	2.1 Mozuku, Tonga	2.1.1 While Tongan species is said to be superior in taste to the Okinawan, high cost of production, processing (refrigeration) and transport has made it very uncompetitive in the sole market, Japan	▪ Potential for the production of extracts for health and beauty formulations being mulled; So far no follow up action
		2.1.2 Subsidized inputs seen as a strain to government technical and funding resources; also considered counterproductive by removing incentive for better farming	▪ Government of Fiji looking for alternative model; However it sees subsidy to small subsistence farmers as a socially oriented service
3. Cheaper substitutes in the local market	3.1 Mullet in Tonga	3.1.1 Cheaper imported species would make cultured product uncompetitive	▪ No action taken except sell wild caught mullets, which is more expensive but preferred by local population
4. Overproduction	4.1 Pearls	4.1.1 Commoditization of a luxury item can debase its value	▪ Example of action is from French Polynesia: placed a limit on quantity, focused on quality

Summary:

- Subsidies were meant to encourage the adoption of aquaculture and later to relieve the farmers of the high cost of acquiring inputs. The policy objective was achieved but the subsidies have tended to become permanent and more generous. This has eventually become counterproductive on three counts: they strain the resources and capacities of government R&D services; weaken the motivation of farmers to do more than simply take care of the crop; and stunt the growth of the private service sector that could more efficiently use national resources or, in partnership with government and academia, enhance the provision of upstream and downstream services under a market regime.
- Lack of competitiveness in world trade of certain commodities - with the exception of pearls, corals and aquarium size giant clams - is almost an intractable problem because of remoteness, transport costs, limited cargo space, and economy of scale.
- A limited domestic demand also limits expansion of production.
- The fear expressed by the pearl farmer in Savusavu, Fiji, that commoditization of pearl would reduce its value has historical evidence: In the French Polynesia pearl industry, continued mass production - 12.7 t in 2000 - led to a collapse in the price of pearl. Measures by government to limit quantity and focus on quality arrested this decline to some extent.[5] This issue is critical because pearl is not only the highest export earner in the Pacific (USD176m in 2007), it also provides employment from its farming to its sale and for its ecotourism value.

d. *Social issues*

Social issues are complex. To put this feasibility element in simple terms, environmental and social responsibility can be assessed by asking, "Is anyone harmed?" A negative answer indicates social acceptability of an operation. The positive side of the same coin is the answer to the question, "Does society benefit from this farm?" This is a more difficult question because it demands setting up the appropriate criteria and measurable indicators of whether society benefits more than it is harmed by a farm. The objective of this analysis does not yet warrant this quantitative methodology.

Social Issues	Cases (Species, Country)	Impacts on project feasibility	Action taken
1. Land ownership	1.1 Tilapia in ponds in Vanuatu 1.2 Freshwater prawn in Palau	1.1.1 In both cases, owners take over pilot farms but could not replicate government success	▪ Projects not resumed by government
2. Communal ownership	2.1 Seaweed transplantation in Cook Islands	2.1.1 Island Council rejects transplantation on perceived ecological harm	▪ Transplantation attempt aborted; seaweeds brought to Aitutaki marine lab instead
	2.2 Pearl farm in Raki Raki, Fiji	2.2.1 Lease kept increasing every time it was up for renewal and farmer-owner kept moving his farm	▪ Owner finally bought a small island and secured long term rights to set his farm in the waters around the island
	2.3 Pearl farm in Savusavu, Fiji	2.3.1 Long term lease needed; expansion of farm requires leasing a larger body of water	▪ Pearl farm provides employment and is one of the economic drivers in the community; pearl company set up its own code of practice (COP) for social and environmental responsibility; COP part of its image promotion and marketing strategy

[5] Ponia, B. 2010. A review of aquaculture in the Pacific Islands 1998-2007: tracking a decade of progress through official and provisional statistics. SPC, Noumea, New Caledonia, 38pp.

3. Access to water body	3.1 Tilapia cage culture in Vanuatu	3.1.1 Degraded freshwater lake made available to entrepreneur; No settlement nearby that is affected	▪ Cage culture is flourishing and providing employment to locals and fish for the local market.
4. Livelihood priorities	4.1 Seaweed vs. copra in Kiribati	4.1.1. When copra prices go up, farmers tend to neglect the seaweed	▪ Seaweed farming ceased, except on one island
5. Acceptability of species as food fish	5.1 Tilapia in most of the PICTs	5.1.1 Populations of most PICs, except Kiribati, subsequently found the fish acceptable	▪ Improved strains such as GIFT and Chitralada were later introduced and promoted for farming
6. Social dysfunctions	6.1 Siganid and grouper breeding in Marshall Islands 6.2 Mullet cage trials in Tonga	6.1.1 Siganid trial stopped when the broodstock-age fishes vanished from the outdoor tank 6.2.1 Mullet trials abandoned when stocks started disappearing	▪ Siganid work stopped; grouper broodstock development continues ▪ Local mullet species now only captured; other species imported for the local market, which is cheaper then the wild caught and preferred local species

Summary:

- The traditional ownership of land and jurisdiction of water bodies by communities - except in open-access Tonga - have tended to favour community-based management projects particularly the protection of seeded stocks in reseeding programmes. But this has also discouraged investments from outside or prevented investors from expanding or making durable improvements on physical assets owing to insecurity of tenure. Tonga's open access regime removed the incentive for communities to protect their coastal resources, which had to be remedied by the establishment of Special Management Areas[6].
- Freshwater fish, specifically tilapia and carps have become acceptable especially with the introduction of the Nile tilapia improved strains. Its broader implication is the role of freshwater aquaculture in making up for the decrease in inshore fish resources from various impacts.

  Social dysfunctions usually discourage farming and abort trials. Stock protection is limited and a high level of security adds to costs. While aquaculture cannot by itself mitigate social dysfunctions, it should at least not exacerbate them with irresponsible practice.

2. Sector Governance

An analysis of the challenges to sustainable aquaculture conducted by the World Bank (2007) described the elements and attributes of a governance framework:

"An effective governance framework embraces policies and regulations moulded by a clear vision of the future for aquaculture and a road map to realize the vision. The policy framework will address issues of equity and strategy including:

- principles for use and allocation of the public domain that include land and water bodies and supply of freshwater;
- a socially required balance between small holder and large aquaculture;
- coherence with other policies and strategies such as those on poverty alleviation, industrial development, water and land use, rights of indigenous people or regional priorities;
- environmental sustainability, including mitigation of social and environmental externalities;
- clear definition of the roles of the public and private sectors;
- sector leadership and coordination; and
- aquaculture fiscal regime."[7]

[6] Povided by Fisheries Management Act 2007, which prescribes the right to a local community to manage its coastal fishery ressouces

[7] The World Bank. 2007. Changing the Face of the Waters: The Promise and Challenge of Sustainable Aquaculture. The World Bank, Washington DC, 188pp.

This review uses this statement as a "benchmark" for the mission's findings.

a) *Policy*

Many of the countries have only recently developed policy instruments specific to aquaculture. A number of countries however have enacted specific acts stating policy and containing regulations, others have gone ahead to formulate a national strategy and plan (FAO SAP and SPC, 2010). The policies and strategies are in line with the national policies and strategies on food security, poverty alleviation, environmental sustainability and industrial or commercial development.

The overarching set of policy goals are the five goals for aquaculture development adopted at the Second Regional Meeting on Aquaculture organized by the SPC in November 2006 in New Caledonia, as follows (2007)[8].

- Create a range of options for rural livelihoods to reduce urban drift
- Improve food security
- Improve the trade balance: more exports and less dependence on import
- Capitalize on the region's comparative advantages: pristine environment, low incidence of fish disease and high biodiversity to produce premium products
- Restore severely depleted fisheries

To these goals has now been added a sixth, "**resilience and adaptation to climate change impacts**," which was emphasized in the 2009 South West Pacific Agriculture Ministers' meeting in Niue and suggested at the informal meeting on Pacific aquaculture held in conjunction with the Global Conference on Aquaculture in Phuket, Thailand, on 22-25 September 2010 (FAO and SPC, 2010)[9]. Climate change impacts would of course include exacerbation of poverty by the destruction or reduction of existing livelihood options, food insecurity and environmental degradation. Its threat has provided the impetus for governments to develop climate change mitigation strategies, incorporating these into national programmes and, for some governments, creating special bodies to deal with the climate change issues. The PICs are generally considered as more vulnerable than most regions to rising sea levels, likely more frequent cyclones, erratic precipitation, and warming and acidification of the seas.

The social objective for fisheries and aquaculture development is common to all the policy statements of the PICs and is suitably expressed in the Fisheries Act of the Cook Islands, thus: "Social and cultural equity should be promoted by maintaining traditional forms of sustainable fisheries management; protecting the interests of artisanal fishers, subsistence fishers and island communities and ensuring their participation in the management of fisheries and aquaculture; and ensuring the broad participation by the citizens in activities related to the sustainable use of marine resources."

The most recent policy objective of the region which has taken traction in the discussions on aquaculture development in the Pacific is biosecurity. It draws justification from the need for biosecurity to be aligned with, and in support of, the goal of food security and the contention that the rich biodiversity of the region remains as one of its comparative advantages and therefore should be fiercely protected.

The balance between these two groups – the small holders and the large enterprises - is an important principle in countries with many subsistence and small-scale farmers and a few export-geared commercial or an industrial aquaculture sector. This provision is implicit in the policy statements but unclear as to its implementation. However, the customary ownership and control of land and adjacent water space by communities provides the instrument to safeguard the interest of the community from, say, rip- and run- or exploitative development in their area. They can also use the customary laws to

[8]Aquaculture Action Plan 2007, SPC, Noumea, New Caledonia, 31pp.

[9]Building on Progress: Report of the Informal Meeting on Aquaculture Development in the Pacific, 23 September, Phuket, Thailand, 8pp.

promote the interest of the local people when negotiating with outside investors. However, it can be a disincentive to investors for two reasons: lack of security of tenure because of lack of a formal lease contract or, too high a transaction cost by having to deal with central government and the local community.

Another important policy objective for a number of PICs is **commercialization of aquaculture**, which is the driver for two linked policy goals, namely, market access and competitiveness.

Nauru and Papua New Guinea were not covered by the review but the statements of their representatives at the informal meeting highlighted the issue of privatization of aquaculture support services and the broader role of aquaculture in rehabilitation of livelihoods. The PNG and Nauru Officers were among five delegates from PIC governments to the Global Conference on Aquaculture and the Fifth Meeting of the Sub-Committee on Aquaculture of the Committee on Fisheries (SCA/COFI V) which followed the global conference. The others were from Cook Islands, Fiji and Tonga. The small farmers of Papua New Guinea are said to aspire to a commercially geared operation[1], white aquaculture is part of the rehabilitation plan for the national economy of Nauru[2].

b) Regulatory and management instruments

Governance of an economic sector is normally executed by a mix of measures including command and control or mandatory (enforcement of regulations), market-based (i.e. certification, eco-labels, etc), voluntary management (adoption of best practices and self-imposed standards reinforced by organizing into farmers associations), and stakeholder participation. The governance of the aquaculture development in PICs largely relies on rules and regulations (see End Notes for a summary by country)[3]. Yet at the community level and in some countries, the clan, a strong element of governance consists of the traditional social norms and customary laws. These often have primacy over legal codes.

Subsidy is a common incentive to encourage adoption of aquaculture or to help farmers stay in the sector. It is a subsidy for production rather than for consumption. It costs the government public funds and probably causes inefficiency in production. A review for ADB noted that there is significant tilapia, milkfish and giant clam culture, but whether net benefits are produced depends on the degree of subsidization, a situation that is often not clear.[10] In Fiji it is now seen as a counterproductive policy because it has removed the incentive for farmers to do more. It might be worth considering some well-targeted subsidy rather than a blanket subsidy for seed, feed and even harvesting, for all scales of farmer (except the pearl farmers). Market based incentives are not a common management instrument. There are also provisions for the development of voluntary codes of practices and a few farms adhere to their own code of practice but it is not a widespread management instrument. Aquaculture associations are rare. There is an association of giant clam producers in Palau and an industry association of Commercial Fisheries Enterprises in Tonga. A Fiji pearl farmers association was organized with the assistance of the government, but it is not certain what its role and activities are.

As can be expected environmental regulations are prominent in the fisheries/aquaculture, agriculture or environmental acts. Palau and the Marshall Islands have strict environmental regulations (with Environmental Impact Assessment provisions) patterned after the U.S. Environment Protection Agency (EPA) regulations.

Assistance has been provided by various organizations including FAO, World Fish, ACIAR, SPC and Japan International Cooperation Agency (JICA) in the development of policy, regulation, strategies and commodity plans. Assistance in biosecurity, including risk management and very specific health management has been provided in some countries as in Federated States of Micronesia (FSM), Marshall Islands and Palau.

[10]Gillett, R. 2009. The Contribution of Fisheries to the Economies of Pacific Island Countries and Territories. Asian Development Bank, Australian Agency for International Development, The World Bank. Secretariat of the Pacific Community and Forum Fisheries Agency, ADB, May 2009, 372pp.

Ownership of property is mostly under the traditional or customary laws, with land under communal ownership and the coastal zone and inshore waters under the adjacent community's jurisdiction. Tonga is the exception: coastal waters had been declared by the monarchy as open access.

c) Capacity building

The 2007 SPC Regional Meeting on Aquaculture identified the critical gaps in capacity as follows: few hatcheries and skilled technical staff, poor capacity to supply high-quality feeds based on local ingredients, lack of policies and processes for enabling and regulating aquaculture, and lack of business and marketing skills, inadequate biosecurity and quarantine procedures. Recent forums have added two more, namely, the poor capacity for collecting aquaculture statistics and lack of capacity in biosecurity that includes risk analysis.

The building of R&D capacities in the region has gone hand in hand with the introduction and trials of various species for commercial aquaculture. This started in the late 1930s and early on almost all of the projects came with expatriate technical assistance that included the establishment of hatcheries (especially those for giant clams and other mollusks and followed by hatcheries for finfish, shrimp and then pearl oysters). Local personnel involved in the establishment and management of these projects were sent to training programmes in various countries so that they could take over the management as well as research and development activities to sustain the projects. This was the case in Kiribati and Fiji, for instance. Regional education and training started with the establishment of the marine and aquaculture programme of the University of the South Pacific (USP), itself strengthened first with expatriate staffing and later with advanced training for local staff in academic institutions in Australia, Japan, New Zealand, the US, and other countries. Technical level education and training are provided in Palau and Marshall Islands by their land grant colleges (College of Marshall Islands or CMI and Palau Community College or PCC), which also have set up their fisheries and aquaculture research and development programmes often with collaborative activities with the government's fishery arm.

Aside from formal education, personnel of government fishery services and farmers have been trained in the region as well as in programmes outside the region such as Asia. SPC, which is an associate member of NACA, has collaborated with NACA in conducting study tours and practical programmes in research centres in Southeast Asia for farmers and technical personnel from the Pacific. The integrated fish farming course in Wuxi, China, has trained many technical officers from a number of countries such as Palau, Fiji, Papua New Guinea, Kiribati and Samoa. Some of the earlier trainees eventually assumed management or research management posts in their fisheries services. JICA continues to provide regional or national training assistance. Advanced degree programmes have recently been an increasing area of capacity building, usually supported by donor and development agencies such as ACIAR, JICA as well as SPC as part of national or regional assistance projects.

Practical field training for students of marine sciences and in-service training for recruits into the government service are conducted in Fiji. Research stations also offer their facilities for student research with the senior staff of the stations in the panel of research advisers to students. It is not widely practiced but a masters student conducted her thesis in the private pearl farm in Savusavu, Fiji, an arrangement that could be expanded.

Other modes of capacity building have included seconded and volunteer researchers and scientists some of them bringing their own research funding support. They would be assisted by young or junior researchers or work in collaboration with the more senior R&D workers of the government research facility.

d) *Institutional development and linkages*

A long period of sustained R&D work assisted by various institutions has laid down a fairly strong technology base for aquaculture development. In Fiji, for instance, government-academic alliance, made possible with the presence of a center of excellence, the USP, has been a strong impetus to

technology and manpower development. This has in turn facilitated and increased the value of assistance from donors and development agencies. The institutional capacities built over the years need to be sustained and strengthened even more. This has to be a primary goal of external technical assistance to the region.

Since the 1930s, numerous external organizations and institutions have initiated research, development and commercial projects in the various countries and territories followed by the establishment of regional institutions.

In the second half of the 1940s, the South Pacific Commission, subsequently renamed Secretariat of the Pacific Community was established. In the 1960s to the 1970s, the South Pacific Islands Fisheries Development Agency initiated trials of a few indigenous and many introduced species and built R&D facilities. In 1981, the Pacific Islands Conference established the Pacific Islands Development Program, which organized the PIDP Aquaculture Project. It documented aquaculture activities in each country and examined specific research topics including aquaculture development. The US Peace Corps began to send volunteers in the region followed subsequently by the Japanese Volunteers and the Australian Youth Ambassadors.

A regional FAO project, the South Pacific Aquaculture Development Project (Phase 1 during 1986-92, Phase 2 in 1994-99) focused on research and development and manpower training. It also established pilot commercial projects.

The 1990s and early 2000 saw more regional arrangements; the noteworthy ones for aquaculture were SPC's forming an aquaculture advisory unit and the University of South Pacific Marine Studies Program's creating a Lecturer/Senior Lecturer post in Aquaculture. The USP Institute of Marine Resources added aquaculture to its teaching and research programme.

Aquaculture development planning, information, market development and trade were soon added to technology development, utilization and training programmes. Conservation, biodiversity and biosecurity issues emerged, which drew interests and assistance from a number of institutions including non government organizations, as in Kiribati and Fiji. Focus was on marine biodiversity but the interaction with aquaculture soon became recognized, particularly pollution and introductions but also the siting of aquaculture operations in sensitive or vulnerable habitats of indigenous marine species.

During the later part of the century, ACIAR, FAO, SPC, WorldFish, USP, JICA, New Zealand Overseas Development Agency, and others initiated regional and national strategic R&D plans and projects. The Pacific region forged closer technical cooperation with Asia, one of which mechanism was the associate membership of SPC in NACA.

In the Northern Pacific, FSM, Marshall Islands and Palau maintained their traditional ties with institutions in the United States particularly those in Hawaii and Guam, which subsequently included cooperation and assistance in aquaculture. The Palau Community College and College of Marshall Islands draw technical and funding assistance from US organizations including University of Hawaii, University of Rhode Island, and the US Department of Agriculture and others. Palau also established technical relations with the Philippines-based Aquaculture Department of the Southeast Asian Fisheries Development Center (SEAFDEC), from which it obtained technology and technical assistance as well as trained manpower for milkfish aquaculture (expanding to other finfish species like grouper and *siganid*). Other R&D assistance to the Micronesian group of countries are from Taiwan Province of China.

A general outcome of the programmes of the numerous external and regional institutions was aquaculture gaining a higher profile in regional and national development strategies and plans; food security, food safety, and environmental and biosecurity concerns gained prominence.

The impacts included the gradual build up of capacity for research, development and management of projects whether commercially or socially geared, borrowing and adaptation of technology, better skills for production, and even better or more opportunity for market access. Generally however the regional capacity is deemed limited.

III. OPPORTUNITIES FOR ASSISTANCE

1. National Level

The framework for this section is based on the basic goals of the farmer: higher yield, lower cost of production, better economic returns, and fewer risk. These are circumscribed by the three pillars of sustainability of the sector and, in general, the state: economic viability, social responsibility and environmental sustainability. The recommendations address these fundamental farmer's goals and national sustainability objectives.

Where aquaculture is an emerging economic activity, governance and technical support focus on creating an environment conducive for its development, which especially aims at encouraging private investments. At this stage, the government invests in research, technology development and extension to improve technology, quality and reliability of seed and feed, and management skills. Research is followed by pilot demonstration projects to show commercial viability of selected species and farming systems. It also provides the incentive for private sector to take over a large part of these support services especially seed and feed production. All the while it assures private investors in farming and the support services that their investment is protected and duly rewarded with clear policy and regulations. Finally, government and private sector work to explore and develop markets. This would include product development and promotion. Subsequently, other support mechanisms are established to sustain gains achieved in these initial stages and pave the way for expansion. The suggested areas of assistance to put these into practice are described below.

<u>Management and technical expertise</u>

a. *Farm management and technical skills*. Poor farm management and technical skills have largely contributed to slow progress or failures of projects or enterprises. These two weaknesses that were identified by the SPC Regional Meeting in 2007 remain relevant in the reviewed PICS. There are few exceptions, as in government, private and government-private hatchery and grow-out of giant clams for the aquarium trade, pearl oyster farming, milkfish culture in Palau, a shrimp farm and a tilapia cage culture farm in Vanuatu, a USP-managed hatchery and grow out freshwater prawn farm, and small tilapia-chicken-root crop integration in Samoa. These have been described earlier and are analysed in more detail in the country reports as well as in the Note, "Building on Progress".

b. *Extension and training*. These can be improved with appropriate technical advice and well-targeted training. However, apart from a few institutions, the capacities of government aquaculture services for extension and training are also in need of improvement. The skills to establish and manage pilot demonstration projects with farmer groups as well as with private entrepreneurs are needed.

c. *Project planning*. The policy of many governments to promote commercially oriented aquaculture would require skills in enterprise planning, development evaluation and management. A training module could be developed with management schools. Development bank or agricultural bank personnel, extension technicians, NGOs providing microcredit, investors and farmers can be the clients of the training course, which can be offered as a regional course or tailored for in-country training. (A retired permanent secretary for fisheries and marine resources in Kiribati attested to the usefulness to his subsequent managerial responsibility for a fishery enterprise and the milkfish enterprise in Kiribati, of the course in aquaculture project development, evaluation and

management (APDEM) that he had attended as a young technical staff. The course was developed and conducted by the Asian Institute of Management and the Aquaculture Department of SEAFDEC in the Philippines).

d. *The diversification of livelihood options* and the need to produce more food efficiently by, among other ways, increasing cropping intensity, has highlighted the increasing role of integrated farming. Some countries have sent trainees to the Integrated Fish Farming course in Wuxi China. This should continue but the technology and the management skills for integrated farming could be further strengthened and promoted by research and pilot projects in the Pacific countries. Small farmers in Samoa and Fiji are practicing polyculture or integration with crops and livestock; these would need science-based advice to improve yields. A collaborative R&D programme could be developed by government aquaculture agencies with the USP agricultural campus in Apia.

e. *Development of appropriate industry development models*. The history of aquaculture development in most countries in Asia would show that technology was the key to better productivity but aquaculture development was driven by commercial interests, and the rise of the small-scale farmers was facilitated by the success first attained by the larger farmers (WB 2007).[11] An appropriate "business model" for the aquaculture sector is therefore as important as appropriate technology. A study of the suitability of various models for commercially geared aquaculture development is needed for countries like Fiji, Cook Islands, Samoa, Vanuatu, Palau and probably Kiribati. The possible approaches are cluster farming, satellite farming and contract farming. Any one of these would also relieve the government of the heavy responsibility of producing and distributing seed as well as feed, tasks can be taken over by the cluster of organized farmers, or the hub enterprise in a satellite model, or the large farm or firm engaging the smaller farmers in a contract farming scheme.

Incentives to investment

f. *Reward to investments and protection from risks*. It is axiomatic that any investment should be justifiably rewarded and protected from any risk. The government has an obligation to create the environment for investment from the private sector. Generally in most of Asia, Europe, and the Americas, private sector investment in aquaculture has been much larger than public investment. No quantification or assessment has been done for the Pacific region but it does appear that government funds supplemented significantly by external assistance have been the source of investments in aquaculture development. R&D spending is expected to be borne largely by government but credit - usually provided through the market - has not been an important source of capital for aquaculture enterprises. There is no private insurance scheme and government compensation is minimal if any, for damage from catastrophic events. A study of the possibilities of commercial credit and micro-credit could be a start. It could subsequently cover a study on the feasibility of aquaculture insurance.

g. *Capacity for enforcement and compliance*. As to the legal and policy framework to strengthen the provisions that encourage, protect and reward investments, most PICs already have either a law or an act awaiting passage into law. Some countries have received assistance from FAO and SPC in crafting their aquaculture or fisheries legislations and SPC in developing their strategies and plans. This process is no longer of high priority. A high priority area of assistance is the improvement of the capacity of governments for enforcement on one hand and capacity for compliance by the farmers on the other hand. It would be more efficient and less costly to manage the sector if the private sector and government worked to increase capacities for compliance, develop and adopt codes of conduct and better management practices. The pearl farm in Savusavu, Fiji, located on Savusavu Bay has demonstrated the effectiveness of a code of practice as a guideline for

[11] "Changing the face of the waters" (op cit).

corporate social responsibility and as a tool for marketing.[12] The two-pronged assistance on this aspect would thus be the strengthening of enforcement capacities and the development of codes of conduct, BMPs or codes of practices. Development of these voluntary mechanisms requires extensive consultations among the stakeholders, which could be facilitated by government.

h. *Establishing an efficient input supply chain*. A private sector-operated input supply service particularly of feed and seed is barely existent in the PICS reviewed. Either seed is produced or imported by government. The exception is milkfish seed in Palau; the farm imports its seed. This is a difficult issue because of the small demand for these inputs and therefore little motivation for private enterprise to go into seed and feed production. As mentioned earlier some business models of farming could improve this situation. In Palau, collaboration among a state-run and private farm, the government's Bureau of Marine Resources and the Palau Community College involves the development of broodstock to eventually produce hatchery bred seed.

i. *Domestic market development and better market access*. This would add to the incentives for private commercial farming as well as improve competitiveness. It makes the marketing of products and acquisition of inputs economically more efficient. The programme could start with a study of the incentives, disincentives and the sources or causes of inefficiencies in the domestic supply chain and the product marketing system. The result would inform regulatory measures to improve the efficiency of the marketing system, provide the private sector a guide to business strategies for the aquaculture sector, and improve small farmers' marketing capability.

j. *Product handling, transformation and marketing*. The issues attendant to these needs are strongly exemplified by the constraint that scuttled the promising mozuku seaweed farming industry. A re-focus from exporting dried, raw or semi-processed materials to producing extracts that would bear the South Sea origin, contain added value, and be promoted to a wider market (including tourists) might attract private enterprise.

k. *Alliances*. Where they have been formed, the alliances among the farming sector, academic and professional institutions, and government agencies in charge of fisheries have facilitated the identification and solution of problems and fostered access to professional and scientific advice for farmers and private entrepreneurs. An initial assistance to encourage the formation of a national industry alliance or association that includes the development of its programme and professionalizing the association would be an efficient use of resources. This can be an entry point for increasing the participation of the private sector in aquaculture.

2. Regional level

One strategic action and three areas of technical assistance to the region were recommended by the Phuket meeting on Pacific aquaculture. The strategic action is to organize a regional aquaculture development workshop among donor and development assistance organizations and governments, described below. The areas for technical assistance are:

a. Developing a regional biosecurity policy and programme and strengthening the capacity of the region for biosecurity.
b. Strengthening the capacity of the fishery services of the region for statistics and information
c. Establishing a regional or subregional networking arrangement.

a. *Regional programme*. The regional aquaculture development workshop in the Pacific is envisaged to better assess the needs of the region and develop cooperative programmes among international and regional organizations and PIC governments. This envisaged collaborative programme could draw guidance from a set of seven principles identified by a meeting among donor and development agencies in Manila in 2002 that reviewed the characteristics and modes of external assistance.

[12] J Hunter Pearls Fiji Pearling Conservancy. 2008. Draft Code of Environmental Practice for Pearl Farming in Fiji. Savusavu, Fiji Islands. 25pp.

Guiding Principles for External Assistance to Aquaculture (FAO/NACA/SEAFDEC/Mekong River Commission/WorldFish Center 2002, cited by The World Bank 2007)

- External assistance is a catalyst to national initiatives to build their own capacities, not as a substitute for what the governments lack in resources and capacity.
- Relevance of a project is ensured with a broad ownership and participation of governments and national stakeholders in its planning and implementation.
- Sustainability and continuity of a project are reinforced by capacity building of regional and national personnel and institutions.
- Capacity building of institutions is more cost effective when a project builds on existing capacities in the region or country rather than tries to establish a parallel capacity.
- Multilateral and multi-institutional collaborative projects should be designed and coordinated to enable the partners to add value to each other's efforts and results; it can also strengthen capacities among partners.
- A regional programme that reflects the common priorities of governments rather than the overriding interest of one or two participants serves all parties better and draws sustained commitment and interest from all the participants in the programme.
- Design of a project should not make it vulnerable to being appropriated by an interest group.

b. *Institutional strengthening.* This embraces a wide range of efforts but the essential element is the capacity for sector governance. Policy and regulatory frameworks are currently enacted in many PICs with the assistance of various organizations. In most cases, the strategic plans for aquaculture development have been developed. The components for institutional capacity building are described below.

c. *Catalytic assistance to facilitate technical cooperation*. Technical cooperation for technology, expertise and information exchange and materials is a well established mode among the PICs and between them and institutions in Asia, Australia, New Zealand, USA and the EU. This area only needs some strengthening and better targeting of the cooperation on specific and high priority needs. TCDC could include arrangements for joint venture and investments. A TCDC exercise could be carried out to identify priority areas for cooperation, areas of distinctive competence of countries and institutions, and priority needs of participating countries/institutions that can be met by TCDC. A TCDC funding assistance could be raised to facilitate the process.

d. *Statistics and information capacity building*. This could be most cost-effectively provided at the regional level by FAO and SPC. It would be one of the cornerstones of a knowledge networking mechanism, referred to below, and a core support to planning and sector management.

e. *Knowledge network*. A regional networking arrangement is probably the supreme form of knowledge network. There are various networking models that the region can be assisted to study as to their suitability and subsequently establish. Meanwhile, national and sub-regional knowledge networks based on specific interests can be fostered, facilitated by the WorldWideWeb. This initiative is not starting from zero; it can and should build on the regional mechanism for technology and knowledge sharing of SPC.

f. *Best practices*. A compendium on success stories in the Pacific would be an effective vehicle for collecting, analysing and disseminating best practices in the various aspects of aquaculture development from policy and regulation to farm practices. It could include practices in aquatic product transformation, value addition, handling, marketing, and trading.

g. *Education and training*. This underpins all of the above. A regional assistance programme would need to place the highest priority on human resources development. Technical assistance projects

usually include a training component, and this should be maintained.
h. *Trade*. Intra-regional and interregional trade is a very high priority area for study and development but very difficult. It would be useful to include in discussions the private sectors of the countries that are trading partners or potential trading partners.

3. Projects and enterprises
Assistance to particular projects. Aquaculture in the reviewed countries, while diverse, comprises few projects and enterprises. The mission has provisionally identified projects as well as enterprises that need certain types of assistance. There is no established criterion for selecting them aside from the mission's broad and unscientific assessment of their potential benefit to society and that they would collectively or individually demonstrate success factors.

Project or Enterprise	Type of technical assistance	Social importance
1) Milkfish pilot project in Fiji	The entire range of milkfish culture: seed nursing, natural food production; soil and water management; pond management; training of the workers; additional support to complete at least two successful crops	Cheaper fish for the poorer communities whose members are usually wage earners and workers in plantations; project is envisaged to be turned over to the community for management
2) Ecofarm (milkfish-poultry-pig) in Tarawa, Kiribati	Farm management, pond management training for farm workers; alternative seed supply other than wild recruit; effective control of tilapia; better product processing	The 80-ha farm provides a preferred species to the population of Tarawa; the integration can be scaled down to smaller farm size and tried in other areas in Tarawa and outer islands; higher production that can be processed and sold locally as well as exported to neighbouring countries would provide more income to government and employment
3) Small-scale integrated farms in Samoa	Better fish seed, introduction and training of all-male seed production technique; management techniques for an integrated system; better crop cultivars ; better and suitable breed of pigs and chicken	Increases production of food/unit area; adds to food security of clan and community; a good income generating opportunity for the women-in-business groups
4) Giant clam community hatchery in Samoa	Training in hatchery and on-growing; credit; marketing advice	Community-managed hatchery and on-growing adds to livelihood opportunities of rural people; export of clams grown by several communities adds to government earnings and provides multiplier effect from support services (handling, packing, exporting)
5) Giant clam farm in Kiribati	Expansion of hatchery facility; credit	Expansion of seed production would enable farm to engage more families for on-growing
6) Sea cucumber hatchery and stock enhancement in Kiribati	Site selection and management of seeded stocks	Restoring the already depleted resource would provide poor island communities livelihood and income
7) Sea cucumber hatchery and stock enhancement in Tonga	Hatchery expertise; seeding and management techniques; on-site demonstration with private sector participation	Sea cucumber has been a major income source of the country and rural people who harvest them; sea cucumber resource is being exploited rapidly
8) Cage culture farm of tilapia and other finfish in Efate, Vanuatu	Bio-secure hatchery system to produce own seed and seed for other farms	Farm demonstrates the role of freshwater fish in the islands' food security especially that inshore resources are declining. Seed production by the private sector can demonstrate the efficiency of this model for other countries; an expansion in seed production would expand tilapia production in Vanuatu

9) Trochus reseeding in Marshall Islands	Revival of hatchery and stock enhancement programme. Technical assistance in seed production and stocking and management	Restoring RMI's now depleted natural fishery of trochus would revive this source of what used to be a good livelihood for outer island communities
10) Tilapia and freshwater prawn seed production and culture in Cook Islands	Broodstock acquisition and maintenance, hatchery and culture of improved strains of Nile tilapia; prawn broodstock development, seed production and culture	Would improve food security and income generation capacity for rural people; adds to employment
11) Finfish culture in Tonga	Pen and cage culture of mullet and culture of milkfish using wild fry and primary productivity	Mullet has shown it can be a good source of income and milkfish is a fallback food fish for remote communities whose inshore fishery resources are depleted. Milkfish can be raised on natural food, which solves the problem of feed and energy cost
12) The seaweed industry in the Pacific	Pilot processing plant – feasibility study of setting up a pilot colloid (carageenan) processing plant in a suitable PIC	A Pacific-based processing plant would stimulate expanded farming of Eucheuma seaweed in many PICs; keep added value in the region; add more jobs and provide an alternative or supplementary livelihood for small and poor farmers

IV. CONCLUSIONS

Aquaculture in the Pacific had its recorded beginning in 1905 when pearl oyster farming was introduced in the Cook Islands by the Lever Brothers (PIDP, 1984). The project was abandoned when a cyclone destroyed it (PIDP 1984).[13] The PIDP review had no record of any more activity until the later part of the 1930s. The half century period until the 1980s then saw some intensification in the efforts to introduce and develop aquaculture, largely as a commercial activity. Some 44 species were either introduced into or moved around the region. The most notable ones for their lasting and wide impacts are the *mossambique* tilapia, giant clam and pearl oyster. These and a number of the 44 species and, subsequently, another four that were tried for culture have provided the cases from which this regional review drew the lessons, illustrations of success factors, and identification of likely causes of project discontinuance.

Although a pervasive and persistent problem to finfish culture in freshwater and brackish water bodies and lagoons has been posed by the *mossambique* tilapia, the general lesson is that biological and natural constraints to feasibility were not severe except the natural hazards. The threat from climate change however includes exacerbation of biological risks such as excessive algal blooms and disruption of reproductive cycle. Many of the species and systems also showed indications of technical feasibility, notwithstanding the problems with seed and feed and lack of credit. (Feed obviously has not been a factor with the molluscan species such as giant clam, trochus, green snail and pearl oyster, and sea cucumber and corals, and seed has become less of a constraint with these species because of the long experience in the region in their breeding.) Many of those that passed the technical feasibility screen failed to become economically viable and the major constraint was market: poor competitiveness in the world market and limited local market, sometimes exacerbated yet by cheaper substitutes. There are however a number of successful cases, described in detail in the country reports. These are also briefly characterized in the note, "Building on Progress" (FAO SAP and SPC, 2010). The recommendations address the constraints to feasibility.

The essential factor for developing the aquaculture sector is in place, namely, the policy and regulatory framework.

[13] Pacific Island Development Program. 1984. "Review of Aquaculture Activities in the Pacific Islands Region", Pacific Islands Development Program, East-West Center, Honolulu, Hawaii, May 1984. 410pp.

The most important enabling factor – the institutional capacity – needs to be further strengthened. There are many competent personnel trained in aquaculture in the region but not enough to cover the many issues. And the lack of capacity for statistical and information gathering analysis has been repeatedly highlighted in various forums on Pacific aquaculture development, the latest of which is the informal meeting in Phuket, Thailand.

In almost all countries the implementing aquaculture development strategy and plan has been formulated and in most cases ongoing. This development indicates the higher profile that aquaculture has gained in government development plans.

The role of the private sector is usually spelled out in the policies and plans but investment in support services from private business is low compared for instance to Southeast Asia. This is an area that needs more attention from governments. The recommendations address this issue and it is focused on providing the incentives to investment and assuring investors that their investment is protected.

To end this synthesis, the observation is reiterated that the geographical, physical, natural, environmental, cultural and demographic endowments of the Pacific region have been a double-edged attribute: a source of comparative advantage or a cause for limited success in aquaculture development projects. The findings of the project provide illustrations of this double-edged attribute. Managing the development of the sector should thus seek to enhance and reinforce the positive effects of the endowments and reduce the negative. This report describes what, in practice, could be done to gain these twin objectives.

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Annex 1

Regional Overview of Aquaculture Development in the Pacific – lessons learned

Terms of Reference

Under the overall supervision of the Sub Regional Representative for the Pacific, the technical guidance of the FAO/SAP Fishery Officer and in consultation with staff of the Government authority concerned (i.e. Fisheries Administration), other relevant government authorities and private sector in member countries, the consultant will:

1. Prior to a mission to the countries, prepare a short note and questionnaire to be distributed to the countries in consultation with SAP Fishery Officer;

2. Briefly review the past and current national fisheries policy and legal frame work, management, development and strategic plan, in particular sustainable aquaculture development;

3. Review the past and current aquaculture projects and their activities and results;

4. Assess the impact of aquaculture development to date in countries, including technical, economic, social, environmental and institutional aspects with collecting necessary information and data from the government agencies concerned as well as private sector;

5. Document lessons learned to benefit from past experience and overcome the various impediments in aquaculture development in countries based on the findings in the above items 2, 3 and 4;

6. Prepare indicative strategic recommendations on aquaculture development at national and regional levels; and

7. Report preliminary findings to the Government prior to the completion of mission, and submit to FAO/SAP a mission report formatted in accordance with FAO style in MS WORD.

Duration:
Six person weeks including three missions (two weeks each) to member countries (Palau, Marshall Islands, Fiji, Vanuatu, Tonga and Cook Islands) in the region and two weeks at home base.

Annex 2

Questionnaire

A mission to selected countries is being fielded by FAO SAP to work with the relevant fishery authority of government in identifying and describing the important lessons from past and current aquaculture development projects and initiatives. The results of the exercise will inform the (a) development of policy and R&D programmes in aquaculture by governments and (b) the formulation by FAO and other assistance organizations of technical advice and development assistance to individual governments, to a group of states or to the region. The lessons will provide some basis for capacity building of the aquaculture sector. They will help government and development agencies avoid costly pitfalls associated with planning and implementing development projects.

Purpose of questionnaire

The mission will meet personally with the relevant policy and technical officers of the government and as necessary representatives of other stakeholders. In short, the mission will obtain information and views from primary sources. The purpose of this attached questionnaire therefore is to facilitate the process. It does not aim to obtain all the needed information. Rather it will provide specific indications and leads that the mission and the government authorities can focus on. This would improve work efficiency and save time.

Another purpose is to give an indication to government authorities of the issues to be covered by the mission so that they could (i) prepare the relevant materials that the mission will need to study and (ii) alert the appropriate people that the mission will need to meet. This will make the work more effective and systematic.

In this regard, FAO SAP kindly requests a careful study of the questionnaire and as thorough a reply as possible. We would be grateful for a return of the questionnaire to the office of the Regional Fishery Officer of FAO SAP, by email, within 2 weeks from receipt.

Thank you.

Questionnaire

Lessons from Aquaculture R&D Initiatives

A. Titles and brief descriptions of initiatives, programmes or projects starting from year 1990 to present. Please try to categorize each under any of the following categories. If it is difficult, place the activity under "Others" Please number them in Arabic numerals consecutively ie, 1,2 …. n.. . from those listed in I down to VIII.

I. Policy and Planning
II. Research
III. Extension
IV. Education and Training
V. Information
VI. Commercial up-scaling
VII. Public-Private Collaboration
VIII. Others

B. List the major impacts and outcomes of each initiative. (Please use only the number assigned to it in "I" above to identify the initiative).

C. Give at most 3 constraints - other than lack of money if that was indeed a constraint - to the implementation of each initiative that (a) were satisfactorily resolved and at most 3 that (b) were not satisfactorily resolved.

D. Refer to the replies to the first part of "C": How were the constraints resolved?

E. Refer to the replies to the second part of "C", why were the constraints not satisfactorily resolved?

F. Has there been a SWOT (strength-weakness-opportunity-threat) diagnosis, or an equivalent exercise, carried out for the fisheries and/or aquaculture sector?

Thank you for your kind cooperation.

Annex 3

A scheme to determine the feasibilities of a species and its farming system

Purpose: Establish the requirements for the farming system's (species and its production system) biological feasibility, technical feasibility and economic viability as well as its social - including cultural and environmental - compatibility.

Feasibility screens: The questions that need to be positively answered to fulfill each feasibility criterion are the following:

- Biological feasibility - Will the species reproduce in a given environment other than its natural habitat and/or grow to its genetic potential in a confined (rather than natural or wild) environment (as in a cage, tank or pond) ? In brief, will it grow to market size and can it be farmed to an acceptable yield level ?

- Technical feasibility - Are the resources available to reproduce and/or grow the species to its potential market size ? Are the technical inputs available when needed ? The technical inputs include seed, feed, fertilizer, credit, skilled labour, post-harvest facilities and services (transport, refrigeration, processing), market (domestic and export), and technological services (research, extension, information). Is there the farm management and technical skill required to farm the species ? In brief, has the farmer the ability and the means to farm the species to an acceptable yield level with a given resource structure ?

- Economic viability - If the answer to the above is "yes", will it be worth investing money and allocating resources into its farming ? Does it reward an investor to engage in its aquaculture ? Essentially, this requires a cost-and-return determination. The importance of a cost and return assessment is that the technical inputs might all be there but their cost of acquisition might be prohibitively high. Or, the price of the product the market is willing to pay may be lower than the cost of producing it. Economic viability is determined by the costs of the resources and the prices of the products. Economic viability indicates the possibility of the farmer gaining an acceptable level of economic returns from producing a given species under a certain production system. While the main influences are the markets and the prices of inputs and the product, it is also related to farmer's being able to have economy of scale by, for instance, being part of an organized group, as well as the cost of capital. In brief, does it pay for the farmer to grow it ?

- Social, cultural and environmental compatibility - The questions to be answered are, would the production system create conflicts with other resource users ? Is the species acceptable to consumers ? Are the production and management practices acceptable as well as beneficial to the community ? Are the production and management practices environmentally friendly and do not contribute to social conflicts and ecological problems ? In brief, is anyone harmed by the practice or product of farming ?

NOTES

1. **Statement of the Aquaculture Manager, National Fisheries Authority of PNG:**

1.2 The foremost goal of PNG is to meet the food security needs of its 6.5m people. It has the advantage of being able to culture cold and warm water species. Another high priority goal of aquaculture development is to provide alternative livelihoods to the rural communities. There are 15-20 thousand tilapia farmers and they aspire to move out of subsistence into commercial farming. There are now private investments in commercial scale projects. Aquaculture is also used for fisheries management i.e. stock enhancement. The government has set up a mariculture facility to enhance and restock inshore fishery. Tilapia is the main species; the yearly production is estimated at 1000 MT. Quality of seed and adequacy and quality of feed have been constraints. The government aims to privatize seed production and establish nucleus hatcheries. Other species are rainbow trout, barramundi and carp which have been introduced. Native species include *macrobrachium*, red claw, mullet and catfish. The major problem is technical capacity. A major concern is biosecurity.

2. **Statement of the Coastal Fisheries Manager, Nauru Fisheries and Marine Resources Authority:**

2.3 Aquaculture is aimed to contribute to the rebuilding of the country as provided for in the National Sustainable Development Strategy. Milkfish has been a traditional culture species and the programme is to revive it for food security and livelihood as well as for import substitution. Seed will be initially sourced from Kiribati. A national aquaculture association has been organized and the members have strong interest in fish farming. Tilapia is being considered for polyculture. The problems include landowner disputes (government is trying to resolve by providing incentives for the landowners to engage in fish farming), high cost of inputs especially feed, and farmers' technical capacity. Drought is also a significant hazard. Ornamentals are seen as a livelihood and trade species but the source will be wild fisheries and thus the issue is resource management. The impact of aquaculture on inshore waters would thus be assessed and managed.

3. **Summary of management mechanisms for aquaculture in each of the eight reviewed PICs:**

Cook Islands: The provision of the Fisheries Act is explicit on regulations but also encourages the other governance mechanisms. The social, cultural and equity measures explicitly encourage a participatory management regime. There are no specifically designated aquaculture zones but the environment provisions of the Act apply to the location of aquaculture facilities and farms. They describe the characteristics of areas where aquaculture facilities and farms may or may not be sited. The designation of an aquaculture management area should be based on scientific, social, economic, and environmental considerations. The Ministry of Marine Resources Secretary or a local authority prepares the aquaculture management plan for the area. The plan identifies the area, describes the status of aquaculture activities in the area, specifies management measures to ensure sustainable aquaculture; specifies the process for allocating and authorizing participation in aquaculture activity in the area, and makes other provisions to ensure sustainable aquaculture. This regulation serves the broad purpose of ensuring that aquaculture is managed responsibly. It also assures investors that their investments are protected.

Palau: Two key policy documents have been drafted by the government and national fishery stakeholders, with technical assistance from FAO: the comprehensive fisheries policy, the new fisheries legislation i.e. fishery and marine resources act, and the national aquaculture strategy and development plan, which would be incorporated into the fisheries law. Two other documents relevant to aquaculture development awaiting adoption are the Quarantine Strategy and Development Plan and the Code of Conduct for Responsible Aquaculture for Palau. The public sector - central and state governments - has largely led the development of aquaculture since 1970 although recently the clam

aquaculture sector has formed an association that could increase the role of farmers in policy and planning, and a private firm has established a marine cage aquaculture farm.

A review of the marine resources subsector strategy (in 2007) noted two important actions to develop the aquaculture sector: for research and development to be done in collaboration with the private sector and for the private sector to carry on the upscaling of a pilot project to commercialize scale, and the more fundamental need to abandon the development of species based solely on their biological attributes in favour of an integrated approach.

Marshall Islands: The Marshall Islands Marine Resources Authority (MIMRA) has the mandate to manage and develop the fisheries resources. Its functions are to carry out and encourage the private sector, other institutions and donors to conduct or support applied research and culture fisheries development activities; source technical and advisory support for community groups or local enterprises to establish commercial activities based on the culture or enhancement of marine resources found in the RMI. Safeguards are also in place.

MIMRA has recently drafted a biosecurity programme with FAO assistance. There is a strong environmental regulation owing to the unique and fragile nature of the country's terrestrial and marine environments. The Government requires an environmental impact assessment (EIA) of all new development projects that may have a significant impact on the environment.

Kiribati: Kiribati has a few enabling provisions that pertain to aquaculture in the Fisheries Act. There is no specific legislation governing aquaculture. Under the Fisheries Ordinance the "Minister may take such measures as he shall see fit to promote the development of fishing and fisheries to ensure that the fisheries resources are fully exploited for the benefit of Kiribati." The Minister or the President may make regulations that provide for the licensing of fish farms and the regulation and importation of live fish and regulating the taking of coral and seaweed. Responsibility for policy and management matters relating to aquaculture is vested in the Fisheries Division. The Ministry of the Environment and Social Development, through its Department of Environment and Conservation, has some responsibilities in evaluating the impacts of marine development and activities. The conservation regulations impose stringent control measures and requirements for prescribed developments. The approval process for developments requires an applicant to submit an initial environment evaluation report or a development application accompanied by an environmental impact statement. Foreign investors are required to submit a certified copy of the Foreign Investment Commission's certificate together with an application. The Environment Act also controls the discharge of pollution from prescribed premises through the requirement to obtain a licence.

Vanuatu: Part of the strategic action under the aquaculture development action plan is to formulate an aquaculture policy with regulations because there is no specific provision for aquaculture development in the Fisheries Act. The Plan targets the building of personnel and institutional capacity to support and regulate aquaculture development. Continuing efforts will be made to standardize the technology packages for the priority commodities and farming systems for the small scale farmers and for commercial enterprises. There is renewed and increasing interest from entrepreneurs who are investing into the establishment of commercial farms. As of now government does not allow privately run hatcheries.

Fiji: An aquaculture decree was being subjected to consultations and expected to be enacted towards the end of 2010. The law would create an Aquaculture Advisory Council, a Licensing Committee and a Scientific Committee. It would provide for a hierarchy of regulations, policies and plans, and facilitate investments in commercial aquaculture. It has indications for a policy to wean the small-scale subsistence farmers from heavy government subsidy (in seed, feed and even harvesting operations) through such arrangements as cluster or satellite farming, or other suitable models.

Tonga: The main laws related to fisheries and aquaculture are the Fisheries Management Act 2002 and the Aquaculture Management Act 2003. The major provisions and features of the Aquaculture Management Act 2003 empower the Minister, advised by the aquaculture advisory committee, to control, manage and develop aquaculture and any related activity. The Act provides for the development of codes of practice. Failure to comply shall be taken into consideration in the grant or disqualification of any authorisation under this Act. An aquaculture development licence is required to establish an aquaculture operation, which is valid for a period not exceeding 10 years. The holder of an aquaculture development licence or other authorisation shall take measures to avoid or minimise pollution and any harmful environmental impact caused by aquaculture or related activities. Introduction of exotics is regulated: the Secretary may designate any species of exotic fish. No person shall introduce or import, possess, culture, sell or export any exotic fish without the written authorisation of the Secretary.

Samoa: The Fisheries Amendment Act 1999 mandates the Fisheries service to regulate any aquaculture development through the issuance of licenses and terms and conditions for any operations. The Fisheries services have been assisting local operators through technical and management assistance. In 1993 and 1995 it assisted in the import of the red claw crayfish for commercial culture which closed three years later. In 1994, Fisheries assisted in the importation of live clams for the private clam nursery at Namu'a Island. These clams were for restocking and resource enhancement. Aquaculture, mainly though seed production, is used for resource enhancement.

Annex 4

Report of the Meeting
"BUILDING ON PROGRESS"
An Evening On Pacific Aquaculture
23 September 2010, Movenpick Hotel, Phuket, Thailand

Summary

An informal meeting to gather ideas to promote aquaculture development in the Pacific region was held in conjunction with the Global Conference on Aquaculture 2010. It was hosted by FAO FIRA and NACA on the request of FAO Sub-regional Office in the Pacific Islands (FAO SAP) and the Secretariat of the Pacific Community (SPC). The meeting recommended the organization of a regional workshop on aquaculture development to provide a forum for inter-organizational and regional governments' agreement on a collaborative Pacific aquaculture development programme. Development of a regional biosecurity programme and exploration of a regional or sub-regional networking arrangement were also recommended.

A. Introduction

This is the report of a meeting organized in conjunction with the Global Conference on Aquaculture 2010, which was held in Phuket, Thailand on 22-25 September 2010. Twenty-five took part in the meeting, from the following organizations or with the following affiliations: ACIAR, Aquaculture without Frontiers (AWF), ASEM Aquaculture Platform, FAO Headquarters i.e. FIRA and Legal Office, FAO RAP, FAO SAP, FAO-Central Europe, JICA, NACA, University of Ghent in Belgium, Secretariat of the Pacific Community (SPC), the World Fish Center, and the fisheries and marine resources authorities of Cook Islands, Fiji, Nauru, Papua New Guinea and Tonga. The list of participants is Annex A.

B. Purpose

The meeting was hosted by FIRA and NACA on the request of FAO SAP and SPC, with the concurrence of the delegates to GCA 2010 (and to the Fifth Meeting of the Subcommittee on Aquaculture of the Committee on Fisheries or COFI/SCA V) which followed GCA 2010 also in Phuket) of the five Pacific Island countries (PICs). Its purposes were to: (a) *gather ideas from interested and concerned participants of the Conference that would guide future aquaculture development initiatives in the PICs;* and (b) *gather recommendations on how to implement ideas into action*. The meeting programme is Annex B.

C. Procedures

Information on the status of Pacific aquaculture were presented for the discussion which followed. The discussion included recommended follow up actions.

Masanami Izumi, Fishery Officer, FAO SAP, and Timothy Pickering, Aquaculture Officer, SPC, served as moderators of the meeting. They thanked FAO FIRA for arranging the meeting and inviting participants, and NACA for agreeing to host it with FIRA and providing the venue and reserving a time slot. They thanked the leadership and staff of FIRA and NACA for their support as well as their participation.

To serve as background information for the discussions, the officers of FAO SAP and SPC provided brief overviews of the history and status of aquaculture in the Pacific and persistent and emerging issues associated with its development. Their powerpoint-assisted briefings were followed by short narratives by delegates of the five PICs of the aquaculture development aspirations of their countries and what obstacles prevent achieving these aspirations.

D. Overview of Pacific Aquaculture

1. FAO SAP. Masanami Izumi, Fishery Officer

The presentation summarized the Note, entitled BUILDING ON PROGRESS: AQUACULTURE IN THE PACIFIC. Prepared by FAO SAP and SPC as background information for the meeting, the Note appears as Annex C. The "Note" contains a brief history of aquaculture development, brief descriptions of selected enterprises and projects that have achieved a degree of success and some initiatives that failed, and a brief analysis of the issues associated with success and failure.

The presentation outlined the agreed regional goals of aquaculture development in the Pacific (development for what?), the assets, comparative advantages, progress attained so far and the concomitant experiences and lessons that the Pacific Region possesses (on what?), the institutions, expertise, programmes and established procedures that could be employed to develop aquaculture further (with what?), the constraints, hazards, and handicaps (against what), and the possible ways, examples and models to adopt or adapt for the Region (how?).

2. SPC. Timothy Pickering, Aquaculture Officer

The presentation described persistent and emerging issues, particularly those that impede aquaculture development in the Region. Within a global context the Pacific islands region can be considered a "least aquaculturally developed" region, but one with vast aquatic resource potentials. Fish for food security will be urgently needed to fill a growing "fish gap" driven by population growth and climate change.

It was noted that there seems to be a contradiction between the goal of food security, which the region's governments have unanimously embraced and are working towards meeting, and the concern for bio-security. "Alien" species are often wrongly equated with "invasive" species. Contradictory dialogues in food security and biodiversity confuse policy makers. Aquaculture species are no different from agriculture species that keep people from hunger. Alien species for aquaculture urgently need research to fill knowledge gaps. Appropriate guidelines need to be developed that allow governments to make considered decisions.

Capacity in biosecurity to safeguard aquaculture potentials is lacking in the region, as is the ability to collect aquaculture statistics to track progress in the sector.

Seawater acidification from climate change is of major concern for the two leading commodities of pearl and marine shrimp. However freshwater aquaculture of tilapia and prawn are expected to be winners under climate change projections and thus offer opportunities for climate change adaptation.

3. Short statements of national aspirations for aquaculture development and constraints.

The five PICs represented in the meeting had some variations in priority species but the common aspirations are food security, better livelihoods, import substitution and/or earnings from export. The prevalent constraint is the shortage of skilled personnel for production, management and planning of aquaculture development projects and programmes. A summary of the statements follows:

i. **Cook Islands.** Koroa Raumea, Director Aquaculture and Inshore Fisheries, Ministry of Marine Resources. Pearl culture, a high value and top aquaculture export earner, has been having problems from disease and efforts are ongoing to solve the problem. Meanwhile, other species are being explored - or revived - for culture, to meet food security goals. These include tilapia, prawns and milkfish. Other species are geared to the fairly significant tourism industry (an average of 100,000 arrivals a year) such as prawn. The freshwater species are also seen as substitute to reef fish, which is a decreasing resource and often affected by ciguatera. The next aquaculture development plan, which will focus on these objectives, commences in 2011.

ii. **Fiji**. Gerald Billings, Principal Fisheries Officer, Fisheries Department.
Fiji aquaculture is carried out in three environments, fresh, brackish and marine waters. For marine, trochus is reared in hatchery for reseeding and supply to neighbouring countries, seaweed is for livelihood with an eye on export, pearls are a high value export earner which contributes to coastal community livelihoods, and ornamentals including giant clam, corals and live rock are for export, but the culture and harvest also support coastal dwellers' livelihoods; for brackishwater, shrimp is for the local market and as an import substitute, and milkfish is for food security and livelihoods; for freshwater, tilapia, carps, and freshwater prawn are for food security and protein, usually for extended families. Freshwater and brackishwater species hatcheries and research stations have been built. Aquaculture is being reorganized as a separate entity from inshore and coastal fisheries. The urgent need is capacity building for the aquaculture staff, for new graduates being taken into the service and for the numerous small and medium scale farmers. Fiji has been proposed as the Regional Aquaculture R&D Centre for the South Pacific. It hosts the University of the South Pacific main campus. USP and other universities use the R and D facilities of the government for internship and research.

iii. **Nauru.** Monte Depaune, Acting Manager, Coastal Fisheries, Nauru Fisheries and Marine Resources Authority.
Aquaculture is aimed to contribute to the rebuilding of the country as provided for in the National Sustainable Development Strategy. Milkfish has been a traditional culture species and the programme is to revive it for food security and livelihood as well as for import substitution. Seed will be initially sourced from Kiribati. A national aquaculture association has been organized and the members have strong interest in fish farming. Tilapia is being considered for polyculture. The problems include landowner disputes (government is trying to resolve by providing incentives for the landowners to engage in fish farming), high cost of inputs especially feed, and farmers' technical capacity. Drought is also a significant hazard. Ornamentals are seen as a livelihood and trade species but the source will be wild fisheries and thus the issue is resource management. The impact of aquaculture on inshore waters would thus be assessed and managed.

iv. **Papua New Guinea.** Jacob Wani, Aquaculture Manager, National Fisheries Authority. PNG aquaculture faces generally the same issues as the Pacific Island nations, but its foremost goal is to meet the food security needs of its 6.5m people. It has the advantage of being able to culture cold and warm water species. Another high priority goal of aquaculture development is to provide alternative livelihoods to the rural communities. There are 15-20 thousand tilapia farmers and their aspiration is to move out of subsistence into commercial farming. There are now some private investments in commercial scale projects. Aquaculture is also used for fisheries management, specifically for stock enhancement. The government has set up a mariculture facility to enhance and restock inshore fishery. Tilapia is the main species; the yearly production is estimated at 1000 MT. Quality of seed and adequacy and quality of feed have been constraints. The government aims to privatize seed production and establish nucleus hatcheries. Other species are rainbow trout (20 MT a year), barramundi and carp which have been introduced. Native species include *macrobrachium*, red claw, mullet and catfish. The major problem is technical capacity and a major concern is biosecurity.

v. **Tonga.** Poasi Ngaluafe Fale, Principal Fisheries Officer, Fisheries Division, Ministry of Agriculture & Food, Forests and Fisheries.
Livelihood and income for rural communities are the twin goals of aquaculture development. The various species for aquaculture include giant clam which is the top export item. Tonga provides seed to other countries such as Samoa for rehabilitation from the tsunami. Mabe pearl is being farmed by small operators. Stocking of the reefs with giant clam has been facilitated by the establishment of special management areas (equivalent to MPAs), which assures protection of the stocks. The culture of Mozuku seaweed was a promising cash crop for export but has been constrained by market issues. A seed production facility for sea cucumber has been set up to produce seed for restocking. As of now sea cucumber harvests are a significant source of income,

livelihood and export earnings. Capacity of the aquaculture department needs to be strengthened. Farmer training is also a priority.

E. Discussion

i. Biosecurity

The discussion on biosecurity issues raised the following points: that alien species need not be invasive species; that the region's comparative advantage is its low incidence of disease and therefore this should be maintained by a biosecurity programme; and that the introduction or movement of species be guided by a biosecurity measure that protects the wild fishery resources of the region. Biosecurity as a tool for aquaculture development should balance the ecological concerns and food and livelihood goals.

Rohana Subasinghe, Senior Aquaculture Officer, FIRA, recalled the recent initiatives to develop biosecurity policy for the Pacific Islands. Melba Reantaso, Aquaculture Officer, FIRA, pointed out that the high biodiversity in the region makes it critically important to have a biosecurity programme; she informed the meeting of a recent FAO assistance to the Northern Pacific countries, particularly the Republic of the Marshall Islands and the Federated States of Micronesia, in training personnel for risk analysis and developing a biosecurity programme for RMI, FSM as well as Palau. Tim Pickering informed the meeting that the SPC had plans to establish an aquatic biosecurity unit, which has been constrained by funding. SPC has also initiated the development of a biosecurity plan for FSM.

ii. Species and resources

A discussion on resources focused on the most appropriate utilization of species and resources. For instance, Patrick Sorgeloos of Ghent University and ASEAN-EU Aquaculture Platform, suggested that the region or concerned countries explore the use of hypersaline lagoons to produce Artemia biomass for small scale culture and as a high-quality local protein source for shrimp or fish pellet-feed formulations.

iii. Capacity building

The discussion on capacity building, development and adaptation of technologies and management systems focused on the way that technical cooperation can cost-effectively provide what the region needs.

Geoff Allan of ACIAR and Aquaculture Without Frontiers (AWF) described the various assistance being provided to improve hatchery technology, upgrade broodstock, develop better and cost effective feed, and improve the effectiveness of stock enhancement activities. He said ACIAR has special interest and therefore has provided also provided substantial funding and technical assistance to the development of small scale aquaculture for livelihoods and food security in PNG.

JICA's Senior Advisor for the Fishery Sector, Shunji Sugiyama, cited the assistance of JICA to a number of countries such as Vanuatu, where a hatchery facility for giant clam, green snails and trochus has been established and technical assistance is provided to enhance coastal livelihoods and coastal resource management.

NACA's Director General, Sena De Silva, mentioned the various training and study tour programmes that have been arranged by NACA for Pacific Islands officers and farmers and promised NACA's continuing assistance to the PICs through technical cooperation. The PICs are linked closely with NACA through SPC's associate membership.

Miao Weimin, FAO's Regional Aquaculture Officer for Asia and the Pacific, suggested a good assessment of future training needs and expressed the readiness of FAO RAP to closely cooperate with FAO SAP and SPC in this area.

Zhou Xiaowei, Aquaculture Statistician, of FAO's Fishery Information and Statistics Service pointed out that some of the species and commodities such as corals and live rock, which are growing in importance in the region and in trade, need to be captured and reported. The Pacific group mentioned that capacity is generally low for statistics in the region and that in some countries there is no fishery statistics unit. Blaise Kuemlangan, Legal Officer of FAO, highlighted the importance of reliable statistics for development planning and policy formulation.

iv. Follow up activities

Michael J. Phillips, Senior Scientist of the World Fish Centre suggested the networking approach to cooperation among countries and between the Asian and Pacific regions as well as institutional collaboration, to take advantage of comparative strengths in pursuing aquaculture development objectives in the Pacific. He suggested a follow up activity to the informal meeting. He saw a large scope for cooperative action and technical assistance.

Rohana Subasinghe, said there is also a clear need for generating finance, developing partnerships, and forging collaborative programmes among countries, regional organizations, development assistance agencies and donor agencies.

Jia Jiansan, Chief of FIRA noted the highly positive and encouraging comments and suggestions. He stressed the need for a follow up activity and for a group to take the initiative to plan and carry out such activity. For a start, he suggested circulating the report of the meeting to the governments and concerned organizations to generate awareness and support. He added that publishing the meeting report in the next issue of the FAO Aquaculture Newsletter (FAN) would increase awareness and interest. He said FAO has further increased its attention to the development of aquaculture in the Pacific region and in this regard, FIRA will endeavour to allocate more resources for the region. He noted that FIRA was supporting the participation in GCA 2010 and COFI/SCA V of five officers from five Pacific Island countries. In line with this higher profile of PIC aquaculture in FAO, Jia Jiansan said FIRA will be keen to establish partnerships with the other organizations, agencies and institutions interested in Pacific aquaculture development. Noting the various suggestions and comments, he strongly suggested that a regional workshop on aquaculture development in the Pacific be organized in the very near future.

F. Recommendations:

The following follow up actions were recommended:

1. Further assistance from FAO (FIRA) in developing a biosecurity policy for the region in collaboration with FAO SAP, SPC and the other key international and bi-lateral agencies (i.e. NACA, WorldFish, ACIAR and JICA).
2. Conduct of a Regional Aquaculture Development Workshop in the Pacific to assess needs and develop cooperative programmes.
3. Explore the development of a networking arrangement among PICs or groups of PICs (such as Micronesia) to implement technical cooperation and collaborative projects and programmes.

G. Annexes

A. List of Participants
B. Provisional Agenda
C. Building on Progress: Note on the history and status of Pacific Aquaculture

Participants

Annex A

ACIAR/AWF

1. Geoff Allan, Australian Centre for International Agricultural Research (ACIAR) and Aquaculture Without Frontiers (AWF) geoff.allan@industry.nsw.gov.au

ASEM (ASEAN-EU) Aquaculture Platform; Ghent University

2. Patrick Sorgeloos, ASEAM Aquaculture Platform, Ghent University, Belgium; AWF
3. patrick.sorgeloos@ugent.be

FAO

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Provisional Agenda

Annex B

AN EVENING ON PACIFIC AQUACULTURE
Informal meeting on the theme:
"BUILDING ON PROGRESS"

23 September: 1645 to 2000 hours
Venue: Board Room, Moevenpick Hotel

Purposes: The participants from the Pacific Island Countries (PICs) with the collaboration of the FAO Subregional Office for the Pacific Islands (SAP), the Secretariat of the Pacific Community (SPC) and the FAO Headquarters in Rome are pleased to invite you to an informal meeting to:

- Gather ideas from interested and concerned participants of the Conference that would guide future aquaculture development initiatives in the PICs.
- Gather recommendations on how to move the ideas into action.

This is essentially a brainstorming session for an hour and will be facilitated by the FAO SAP and SPC officers. A short report of the exercise will be produced and circulated by the FAO SAP and SPC to their constituents.

Agenda:

1. Findings (highlights and preliminary) of an ongoing FAO Pacific aquaculture 2010 review: Masanami Izumi, Fishery Officer, FAO SAP: 8 minutes
2. Selected issues in aquaculture development in PICTS: Timothy Pickering, Aquaculture Officer, SPC: 8 minutes
3. Brief statements from the 5 PIC participants: 5 minutes each.
4. Open discussions:
   a. What aquaculture commodities/systems are most promising or most in-demand for future actions or engagement with donors?
   b. Is it useful to compile cases for a "Pacific Aquaculture Success Stories" ? If so what cases could be included ?
   c. What to do next ?

Participants: The five Pacific representatives (from five PICs), representatives of SPC, FAO, NACA, ACIAR, WorldFish, SEAFDEC, INFOFISH, other organizations and conference participants who would like to join the evening discussion.

Annex C

Building on Progress

Aquaculture in the Pacific

This Note is a Collaboration Between The FAO Subregional Office For The Pacific Islands and The Secretariat Of The Pacific Community, With Inputs From Koroa Raumea, Cook Islands; Gerald Billings, Fiji; Monte Depaune, Nauru ; Jacob Wani, Papua New Guinea; And Poasi Fale Ngaluale, Tonga, And The Assistance Of Pedro Bueno.

Masanami Izumi, Fishery Officer, FAO SAP
Timothy Pickering, Aquaculture Officer, SPC
9/23/2010

Prepared for an informal discussion session on directions for aquaculture development in the Pacific in conjunction with the **GlobalAquacultureConference 2010**
22-25 September Phuket, Thailand

Vate Ocean Gardens, Ltd, Efate, Vanuatu

Abstract

A short historical note of aquaculture development and a glance at its status in the Pacific Islands set the context for a brief description of selected enterprises and projects that have achieved a degree of success and some initiatives that were discontinued. The examples broadly illustrate the issues associated with the progress of the sector. A brief analysis of the issues is provided.

A floating cage for culture of milkfish in Ngatpang State, Republic of Palau

left to right - a fresh batch of pearls from the farm of JHunter Pearls in Savusavu, Fiji being polished with salt to be followed by granulated walnut; a coral glowing in a darkened viewing room in the public aquarium of Noumea, New Caledonia, and a giant clam in the farm in North Tarawa, Republic of Kiribati, ready to join others in the aquarium trade

Seining for mature *Macrobrachium rosenbergii* for broodstock in a grass carp – giant freshwater prawn polyculture experimental pond of the Naduroulou Aquaculture Station in Fiji

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Building on Progress
Aquaculture in the Pacific Region[1]

A. Purpose of this review

The physical, natural, environmental, cultural and demographic endowments of the Pacific region have been a double-edged attribute: a source of comparative advantage or a cause for limited success in aquaculture development projects. This review illustrates this situation. Cases that have exhibited some degree of success and the factors that contributed to it are described; other cases are provided to illustrate the diverse reasons for failure. The review does not criticize or praise. It is presented solely to generate ideas to build on the progress that the Pacific region has achieved in aquaculture development.

Aspirations for the Region (SPC 2007)[1]

- Create a range of options for rural livelihoods to reduce urban drift
- Improve food security
- Improve the trade balance: more exports and less dependence on import
- Capitalize on the region's comparative advantages: pristine environment, low incidence of fish disease and high biodiversity to produce premium products
- Restore severely depleted fisheries

B. Historical note

The development of Pacific aquaculture may be divided into two overlapping periods by the objectives to which the initiatives are geared. The first period is lengthy, from the late 1930s to 1980, when most culture trials were meant to produce results that could be commercialised. Those that did not perform to commercial expectation were dropped and other species were considered. There was a relatively large number and diversity of species (44), many introduced from other regions or moved within the region, that were tested for commercial production. The goal was largely to generate economic returns. The period thereafter had longer-term objectives, longer time horizons for R and D projects, and gradually embraced social and environmental goals.

Giant clam, an ubiquitous species in the region, is the exception. Its trade for meat and shells had rapidly depleted natural populations, which alarmed governments and their supporters and prompted many agencies to provide generous assistance to R and D in artificial spawning and production of seed to restock the reefs. Initial work was done in Palau; it spread from there. Many of the multi-purpose hatcheries existing today were purpose-built for giant clam. It was eventually found to be a lucrative species for the growing world aquarium trade. This purpose subsequently eclipsed the original objective of enhancing natural fishery or establishing new populations, although efforts to do so continue. Trochus had a similar trajectory. Sea cucumber is following suit.

1. Milestones and highlights[2]

- 1905 – Pearl oyster was introduced for culture trials in Cook Islands by the Lever Brothers; a hurricane stopped the project, nothing else followed until 1982, when a pilot project was initiated in Rakahanga Island in the northern Cook Islands.

[1] From an ongoing review conducted as TCP/RAS/3301 by FAO SAP that covers eight Pacific Island Countries (PICS), namely, Cook Islands, Palau, Marshall Islands, Kiribati, Vanuatu, Fiji, Tonga and Samoa. The project is titled "Regional overview of aquaculture development in the Pacific – lessons learned". It is expected to provide guidelines for project planning and technical assistance. Supplementary and especially historical information were obtained from the 1984 review of aquaculture in the Pacific Islands (footnote 3)

[2] From the "Review of Aquaculture Activities in the Pacific Islands Region", Pacific Islands Development Program, East West Center, Honolulu, Hawaii, May 1984.

- 1937 – Carps were introduced in ponds in Fiji but were washed out in a flood, nothing followed until 1968 when Chinese carps were again brought in for food and weed control.
- 1939 – The first record of a concerted aquaculture activity in the Pacific region, in Fiji; a scientific reconnaissance was made of fishery resources for development and protection; recommendations were made for freshwater aquaculture in ponds and import of species.
- 1940-1950 – The landmark event during this decade, the first half of which saw attention diverted from development, was the establishment in 1947 of the South Pacific Commission, subsequently renamed Secretariat of the Pacific Community.
- 1950-1960 – The period when the mossambique tilapia (*O. mossambicus*) was promoted through almost all of the Pacific countries and territories for culture, enhancement of fishery in freshwater bodies, and control of mosquito.
- 1960-70 – South Pacific Islands Fisheries Development Agency established. Trials of a few indigenous and many introduced species, some R and D facilities began to be established. Pearl farming initiated in French Polynesia.
- 1971-80 – Aquaculture trials for more than 40 species or species groups were carried out in 21 PICTs; more R and D facilities established; manpower development starts. Notably, giant clam research began, in Palau, on spawning, larviculture, culture, reseeding and introduction. By the end of the decade, reliable hatchery production was achieved. The growing tuna fisheries industry spurred trials to culture baitfish (molly, milkfish, even tilapia). Shrimp spawning and culture begins in Tahiti; feed for postlarvae developed; 4 of 10 screened species selected for culture.
- 1981-90 – The Pacific Islands Conference established the Pacific Islands Development Program, which organized the PIDP Aquaculture Project. It documented aquaculture activities in each country and examined specific research topics including aquaculture development. A regional FAO project, the South Pacific Aquaculture Development Project established (Phase 1 during 1986-92, Phase 2 in 1994-99) It focused on research and development and manpower training; some commercial ventures begin to take hold; trade starts. The beginning of 1980s marked the rise of pearl as the top export product of French Polynesia. By 1983, mass seed production of shrimp has been achieved in French Polynesia
- 1991-00 – More regional arrangements and cooperation forged, with SPC's establishment of an aquaculture advisory unit. The University of South Pacific Marine Studies Program established a Lecturer/Senior Lecturer post in Aquaculture in 2000, and the USP Institute of Marine Resources includes Aquaculture in its mandate. Aquaculture development planning, information, market development and trade were added to technology development and utilization and training programmes. Conservation, biodiversity and biosecurity issues emerge. ACIAR, FAO, SPC, WorldFish, USP, JICA and others initiate regional and national strategic R & D plans and projects.
- 2000-10 – Aquaculture gradually gains a higher profile in regional and national development strategies and plans; food security, food safety, environmental, and biosecurity concerns gain prominence. PICTs through SPC establish links with Asia through its association with NACA; Agriculture ministers urge strengthening capacities in aquaculture for food security.

2. Numbers

- 44: the number of species or groups of indigenous and introduced species that were studied and tested for culture in 21 PICTs from 1937 to 1984 (see Annex).
- 49: the total number with the addition after 1984 of corals, grouper, sea cucumber and live rock (as well as mozuku seaweed that became a culture species in Tonga in 1998).
- 9: the number of regional priority species or commodity groups identified in 2007 for livelihood (pearl, seaweed, marine ornamentals, marine shrimp, freshwater prawn, sea cucumber, marine finfish and mud crab) (SPC 2007, Regional Aquaculture Action Plan).
- 2: the number of priority species identified for food security (tilapia and milkfish).
- 211 million US Dollars: the total value of production in aquaculture from PICTs (2007); of this USD 174 million was from French Polynesia, USD 29 million from New Caledonia, and USD 8 million from the others.
- 2: the number of aquaculture products – shrimp and pearl – that make up much of the USD 211 million.

Notwithstanding limited success, the great diversity of species introduced or tried for culture between the 1950s and 1980s has served useful purposes. The screening and winnowing of species and their farming systems:

- filtered the ones that were suitable for the region's agro-climatic conditions, relevant to the economic conditions, and compatible with social and cultural traditions;
- drove the establishment of facilities for research, culture trials and pilot demonstration;
- improved capacities for research and extension as well as enterprise management;
- successful and failed projects informed better the subsequent R and D projects, commercialization attempts, and the formulation and implementation strategy of assistance programmes of the agencies and organizations that operate in the region.

The tilapia mossambica merits a special mention. Introduced in the 1950s, established and proliferated in lakes, rivers, lagoons and estuaries in almost every Pacific country and territory, it has arguably become a pest or nuisance. But, it did become a sustained fishery resource in some freshwater bodies (as in Solomon Islands, Atiu in the Cook Islands and Sepik, Papua New Guinea). It also introduced people to the taste of freshwater fish, raised awareness of governments on the importance of a food security or fallback species when sea fish is scarce, and served as a precursor to the introduction and trials of the improved strains.

C. Overview: Issues, lessons to build on

Aquaculture in the Pacific has not seen the same rapid and dynamic pace Asia had. This is a general statement. There are bright spots in terms of commodities, species and areas. For example:

- Marine shrimp in New Caledonia and French Polynesia, and a private commercial-scale shrimp farm in Vanuatu
- Pearls in Cook Islands, French Polynesia and Fiji
- Ornamentals including corals, giant clam and live rock in a number of North and South Pacific countries where purely private or government-linked culture and export operations have taken hold or are flourishing as in Fiji, FSM, Kiribati, Marshall Islands and Tonga
- Milkfish in ponds and cages in Palau and in ponds in Kiribati
- Tilapia in Fiji, Papua New Guinea and Solomon Islands for small subsistence producers; Vanuatu with a private enterprise; and to some extent Samoa, with some small integrated systems (vegetables, taro/pig, chicken/tilapia)
- Macrobrachium in Fiji
- Seaweed in Kiribati and the Solomon Islands

1. Feasibility indications

The findings from the numerous species trials, aquaculture projects and studies did not provide the countries with adequate answers to immediate development needs; commercial upscale of pilot projects is rare. The drawbacks have included natural hazards, biological problems, some social issues, and technical and economic constraints. Technical shortcomings are related to financial resources, technical capacity and infrastructure, management and technical skills, access to technical advice, marketing channels, technical information collection and dissemination, seed sources and feed materials. Natural disasters (cyclones, drought, flood, tsunami) have time and again disrupted promising trials. Some were resumed, most were abandoned.

Technical feasibilities have been demonstrated; a handful of species/systems passed the technical feasibility filter and moved into commercial application. Many could not be sustained because of issues associated with marketing (a limited local demand) and poor competitiveness (for export products as well as for locally sold products that face competition from cheaper imports or wild fish).

Lack of competitiveness in world trade of certain commodities -- with the exception of pearls, corals and aquarium size giant clams -- is almost an intractable problem because of remoteness, transport costs, limited cargo space, and economy of scale.

Small farmers and communities could earn supplementary income from some of the species that are compatible with their livelihood strategies like seaweed and giant clam. But low value products with high volume such as *Eucheuma* seaweed earn low returns for both growers and government whereas high value species like giant clam and trochus have a very lengthy turnaround period. Nonetheless, seaweed growers on Fanning Island in Kiribati and in Solomon Islands continue to produce red seaweed, shipped to a distant processing plant outside the region. Private as well as government–linked operations on giant clam hatchery, grow-out and trade provide good examples of hatchery success (Palau and Tonga), the important role of a farmers' association in partnership with government (Palau), mutual benefits of a business-like arrangement between an exporting company that has a hatchery and small growers (Kiribati), and the role of government in providing extension services and organizing farmers (Marshall Islands).

Local markets are generally limited for food fish. But a fine example of local marketing strategy has been displayed by the tilapia cage farmer in Efate, Vanuatu; he programs his production schedule so that he can harvest market-size fish when wild caught fish is scarce due to inclement weather or seasonality of catch. This has a broader implication: it underlines the role of aquaculture in food security in the islands, supplementing a generally dwindling inshore fishery and offering some tolerance to climate change impacts.

2. Incentives to investments

Governments have been keen to see commercial development. Some have adopted a dual approach: encouraging commercial development as well as supporting -- invariably with heavy subsidies -- small subsistence producers (of tilapia and prawn) and growers (of giant clams and seaweed).

Governments have drafted or are enacting legislation specific to aquaculture, and formulating a national policy, strategy and plan for aquaculture development to guide, promote and regulate aquaculture development and investments.

Fiji for instance has a pending aquaculture decree, an overarching statute that will provide for a hierarchy of regulations, policies and plans. It should facilitate investments in commercial aquaculture. It has indications for a policy to wean the small-scale subsistence farmers from heavy government subsidy (in seed, feed and even harvesting operations) through such arrangements as cluster or satellite farming. Palau and Marshall Islands have drafted their respective policy frameworks and development plans. Vanuatu has an aquaculture development plan, 2008-2013, and is working on a draft legislation on aquaculture. Solomon Islands has a tilapia aquaculture action plan 2010-2015, Samoa has a draft aquaculture law being submitted for enactment, and Tonga, which in 2003 passed an aquaculture management act, has launched its aquaculture commodity development plan 2010-2014. Fiji is also reviewing the freshwater aquaculture action plan of 2005-2010

Biosecurity measures to buttress the existing quarantine protocols are now built into aquaculture regulations. It is timely, too, as movements are happening and species identified for yet another round of introductions include shrimp.

Food security has joined livelihoods as a priority task for aquaculture: in 2009, a meeting of Ministers for Agriculture of several Pacific countries urged countries to further strengthen their capacities in the "sustainable development and sound management of aquaculture" so that it contributes better to food security. (They requested FAO to undertake a regional review to identify lessons on which to build development assistance and plans).

3. Property issues and resource management

Land access rights and water jurisdiction issues have sometimes thwarted planned projects, caused the abandonment of promising pilot projects, or discouraged investment. On the other hand the traditional communal property ownership has facilitated the adoption of technology, improved the effectiveness of community-based management of coastal resources that include seeded clams and

trochus, as in Palau, Samoa and Fiji. However, the open access regime of Tonga has tended to remove the incentive for the local community to protect the resources in its coastal waters. This has prompted the government to establish eight Special Management Areas.

Lease of coastal water by private operations in coral and pearl farming includes arrangements for the company to contribute a percentage of its income to a community trust fund. Employment opportunities open for the people in diving, caring, collecting spats, and limiting environmental impact. Some, like the pearl farm in Savusavu, Fiji, provide scholarships to the youth in the community and encourage youth participation in environmental campaigns. The same farm has formulated its own code of practices that assure social and environmental responsibility.

D. Examples: success factors, risks, constraints

A selection of projects, described below, provides brief illustrations of the success factors as well as constraints to the projects. Taken together, the success factors are not new or different from those of any successful commercial or development project. Although their relative importance differs with each case, the common factors are the availability of technical advice, technical inputs and a market. Two cases, in Palau and Samoa, point to the value of an industry champion. Some confirm that an appropriate business model is as important as appropriate technology.

1. Tilapia cage farm, Vanuatu

a. Locally-based entrepreneurship and a good domestic market for fresh fish; technically, the factors that contributed to the success of the private farm are (i) the use of 'appropriate technology' and a proven technology for tilapia culture; (ii) the availability of a local water resource that had already been degraded by deforestation and infested with noxious fish species; and (iii) the availability of local feed ingredients.

b. Seed has to be imported due to regulations placed upon business by the Quarantine Department. A hatchery has been constructed and tilapia (and barramundi) will be bred in Vanuatu in the future (if approval is provided) and seed mass produced for smaller scale farmers in the region.

2. Giant clam farming and export for the aquarium trade, Kiribati

a. A workable business model based on trust was forged by the entrepreneur and the small growers. There is a well known and already standardized hatchery and culture technology in the Pacific region. The company produces spats reared to a suitable size in its hatchery and nursery complex, and distributes these to selected farmers in two nearby atoll communities for on-growing to aquarium size, before buying them back and exporting them to an aquarium company in Germany. The farm also provides the nets and technical advice and buys in cash twice a year, before the independence day and before Christmas. Company and Kiribati government have received assistance from SPC on compliance with CITES requirements.

b. Energy costs and reliability reduces efficiency and increases cost, capacity for expansion is limited, a limited number of skilled growers to support production expansion.

3. Pearl farm in Savusavu, Fiji

a. The farm's comparative advantage is the ability to produce high quality pearls of colors different from the ones grown in French Polynesia and Cook Islands. It has an effective marketing strategy backed by a high-fashion promotional campaign and supported by an image of corporate social responsibility; it has developed its own code of practice addressing social and environmental issues. It provides a percentage of its income from sales of pearl jewelry in its showroom to a community trust fund, which is a sizeable part of its total sales generated from tourists who come in yachts and by cruise ships. It is one of the tourist stops in Fiji. It has established a hatchery that allows it to control the quality of oysters and support 15% of its seed requirement; much of the seed is collected for which it employs collectors, or buys from collectors who come from the community. It employs on a fixed fee basis, (rather than on percentage of the good pearls) three highly skilled nuclear implantation technicians, who help develop innovations that enable the production of pearls with attractive colors. It monitors and maintains the quality and primary

productivity of the coastal waters. It complies with shipping lane provisions and environmental requirements; it promotes environmental campaigns by the youth and donates to the youth fund. It provides scholarships to deserving local students.

b. *A risk to its image and the image of pearl as a high-fashion and luxury good is the commoditization of the South Sea pearls. This would happen if investors flock in and quality becomes sacrificed for quantity.*

4. Milkfish farm in Kiribati

a. There is good consumer acceptance of milkfish both fresh and smoked, which the farm produces and sells. Government's priority species included milkfish, and it decided to establish a milkfish farm in a degraded piece of the Tarawa lagoon. As there was need for expertise to carry on with the initial work from FAO experts, the government sent national staff for higher level technical training abroad (Australia, Japan, The Philippines and Taiwan). Management and technical expertise was therefore locally available. Integration with chicken and pig provides a good model as well as income to operate the farm. Replicating it in scale elsewhere in Kiribati however would technicallybe extremely difficult.

b. *Severe infestation of O. mossambicus, entry of predator fish with the lagoon water, lack of a suitable feed, and an apparent lack of well trained farm workers. Poaching is also a problem.*

5. Milkfish farming in ponds and cages in Palau

a. Milkfish farming has a long tradition in some states of Palau. Traditional extensive milkfish ponds were found around the country. Technology and expertise from the SEAFDEC Aquaculture Department based in the Philippines provided the technical push for the milkfish aquaculture, carried on further with FAO technical assistance in culture and processing. One of Palau's state governments (Ngatpang) followed by a commercial enterprise (NECO) have expanded into cage culture of milkfish for food and bait, following the success of pond culture; broodstock are now being developed in the state government's cages. It will provide the Palau Community College with a multi-purpose hatchery and some of the broodstock for seed production; seed is now imported from Taiwan. Milkfish demand is seen to rise providing opportunities for expanding its culture for the domestic market, as a substitute for imported milkfish and as bait. Local demand and added value has been improved with the introduction, through an FAO technical assistance, of de-boning, processing and marketing the fish. Key impetus, other than a source of technology, expertise and a large local market, is the presence of an industry champion. The former governor of Ngatpang State, now a private businessman initiated the Ngatpang State fish farm and later included the milkfish cage farm among his business ventures.

b. *Seed, low cost feed, skilled local technical workers are technical constraints. Milkfish for export would have difficulty competing with the Philippines.*

6. VAC-like farms in Samoa

a. The introduction of new strains (GIFT and Chitralada) of tilapia, being maintained by the government hatchery has improved the prospects of the small subsistence farms, of which there are 23 in Samoa. The small integrated farms have developed a technique by which they grow all the tilapia of different ages and mixed sex in one pond, then with assistance from government technicians, the farmer selects and transfers males into another pond for ongrowing. Subsistence farms support the food requirement of a clan, which underlines the importance of these integrated VAC-like farms to food security in rural areas. (*VAC is the Vietnamese acronym of garden-fish-livestock, a highly productive small scale farming system popular with Vietnamese farmers*). The owner of one of the farms, a *matai* or head of clan, has inspired a widespread interest by having it featured on Samoan television. The publicity has caught the interest of some religious establishments.

b. *Monosex culture would improve efficiency and yield; pond populations still include the mossambique species, farmers and their families are reluctant to see an empty pond thus hesitant to practice an all-in all-out system. Feed formulation needs improvement. As demand is tiny to warrant a commercial feed venture, government formulates and provides feed (and seed) to farmers.*

7. Macrobrachium farm in Fiji

a. An integrated hatchery and culture operation is under the technical management of the University of South Pacific whose researchers and technicians are running the farm. It has financial backing by the Fiji Dairy Farm which owns it and technical back up from USP and the Naduroloulou Freshwater Aquaculture Centre of the Government; quality broodstock, feed and hatchery and culture technology are available from both. The demand from affluent families and restaurants catering to tourists makes it high priced seafood. It has the potential to be the core of a satellite farming model, supplying seed and technical advice and buying back at market price the harvests of smaller producers around it.

b. Severe flooding in 2009 had wiped out the stocks and severely damaged the farm and hatchery facilities.

8. Integrated fish/livestock (chicken, duck and pigs) farm in Fiji

a. The farm is run by a religious institution that vocationally trains young men who might otherwise become a social problem. It has a good site with running freshwater and a well-laid out farm. Labor is provided by the trainees and the harvest is entirely for their consumption. Technology back up comes from the Naduroloulou Freshwater Aquaculture Centre.

b. Poaching is an occasional problem (of the livestock not the fish although a trial crab on- growing pond was emptied of all crabs).

9. Shrimp farming in New Caledonia

a. It has been sustained by excellent R and D support from the French aquaculture organization in Tahiti and New Caledonia; it has established an export market in Japan, France and Oceania; and the local demand is good from a population that has a relatively high purchasing power.

b. Competition from Asian producers, high cost of transport.

10. Coral and live rock culture and export in Fiji.

a. Walt Smith is a well-established, well-organized, technically efficient operation with market linkages in many importing countries and operations in other Pacific countries. The Fiji operation has established coral broodstock, a hatchery, and coral growing beds in waters that are clean and productive. Local people are trained for the growing and harvesting operations, which comply with environmental standards, and as an added advantage, are located near the international shipping port. Apart from producing live rock, they have also developed an artificial composite rock.

b. Costs remain relatively high, skilled workers are hard to find, and there is a risk that the global market could be saturated. Low-cost production operations from Asia pose a long term problem.

11. Tilapia subsistence farming in Fiji

a. An effective technology backup from the freshwater aquaculture station that produces quality seed, has developed suitable feed, provides sustained technical advice, and other assistance. Subsistence farming produces food not only for one family but for a large extended family, which amplifies the importance of small-scale subsistence farming to food security.

b. Sudden withdrawal of state subsidy would not make the farmers sustainable.

12. Giant clam farming and export in Marshall Islands

a. The Marshall Islands pilot project on giant clam gives evidence that a total subsidy to farmers of materials and seed need not be made to encourage successful adoption. The private commercial sector has demonstrated it can carry out a large part of the essential activities to sustain an industry including seed production and marketing. On the other hand, the role of government in organizing farmers and providing the extension and technical advice – which a private company might not wish to undertake – remains essential. There is scope however in encouraging the private sector to eventually take up these tasks, as is done in the contract farming or cluster model.

b. As yet, few households have the capacity for ongrowing, the on growing is confined to atoll communities near the capital or main island of Majuro.

E. Stillborns and their causes, briefly:

This section does not attempt to analyse the root cause of lack of success. These cases provide specific illustrations of the natural, biological, technical, economic, and socio-cultural issues that prevented projects from succeeding. The natural and biological problems are straightforward and can be severe. The technical issues are always linked to the availability of resources and capacity to access and use them. It is the more complex economic, social and cultural issues that can frustrate projects that have passed the technical feasibility test.

1. Seaweed in Marshall Islands. Seed from Kiribati grew well in the trials. Turtle and rabbitfish predation was very severe. It was abandoned.
2. Macrobrachium in Palau. Very good initial harvests from the trial; land owner then terminated the lease with the Government's Marine Resources Bureau, but could not replicate the success. Interest waned and project was not resumed.
3. Macrobrachium in Cook Islands. Seed from Tahiti grew well in a dammed elbow of a creek (an oxbow) on private property. Harvest was successful and sold for 48 NZ dollars a kilo. Drought dried up the creek, wiped out the stock and the project was not resumed.
4. Green mussels in Samoa. Washed out by a cyclone; also suffered from poaching. The two cyclones, in 1990 and 1991, silted the site. There was however a good local demand for the initial harvests. Government did not resume the project and no investor took it up.
5. Round pearl culture in Kiribati. The trial was intended to explore its economic feasibility and attract local and foreign investors. While production was satisfactory, pearl quality was poor. A proposed alternative was to produce *mabe* or half pearl but no private investor has come forward likely discouraged by poor quality and a high capitalization. No economic feasibility study has been carried out on the production of half pearl to serve as investment prospectus.
6. Mozuku culture in Tonga. Market went flat. Mozuku as food, the sole market of which is Japan, cannot compete with Okinawa's. Processing is labour intensive and refrigeration costs are high. Extracts for medicinal purposes is a promising business venture geared to a niche market; extraction technology is available and the market is good locally and abroad. A product for niche market relies on a comparative advantage, usually its distinctive image. The selling point for Mozuku extracts is that it is from wild seaweed from the South Seas. One entrepreneur fears that being seen as coming from farmed seaweed could reduce its appeal and value.
7. Tilapia in ponds in Vanuatu. The owner of the land on which the pilot ponds were built terminated the lease agreement with government; he could not replicate the success of the government pilot project.
8. Mullet in Tonga. Recruitment of seed, limitation in feed, imported mullet was cheaper. However, local demand is high and the two local species fetch a higher price than the imported species. Culture in pens in the lagoon was stopped. Stock tended to disappear.
9. Siganid in Marshall Islands. A sizeable number of fish had been patiently reared to broodstock size by the government project, with foreign assistance. Every fish vanished when they were transferred to an outdoor tank.
10. Artemia in Christmas Island, Kiribati. Technically feasible, cyst quality was fairly high. It was overtaken by newly developed low-cost production systems in other countries. Also, an effective R and D back up was difficult and costly to maintain because of the site's remoteness. **Patrick Sorgeloos** recommended its shut-down as a commercially geared project, although he suggested continuing small scale harvests for larval feed of shrimp and milkfish then being tried for culture.

In summary, the more than half a century of aquaculture activities in the region has seen a wide range of species and systems tried with varying degrees of success, mostly limited. The diverse base of 49 species groups has been whittled down to 11 regional priority ones, 9 to support livelihoods, 2 for food security. Different species can provide employment, food and income to different segments of the population, complement existing livelihood sources, be incorporated into a mix of farming systems, and target different markets. However, this can also diffuse the effort and strain the resources of the aquaculture unit by having to support the development and promotion of numerous species

and farming systems. The R&D resources of many Pacific countries can be quickly overwhelmed by a multiplicity of research, development and extension issues to address. There can be many and diverse demands from the different island communities on the services of a central R&D organization for fisheries and aquaculture. Similarly, a heavy state subsidy to farmers places an unfair expectation on a single research centre to provide services and materials, which the private sector, in most other countries or industries, can share or even totally assume under a usually more efficient market regime.

F. Conclusion

The essential element to aquaculture development is being put in place by many countries: an aquaculture policy enshrined in a law. It reflects the prominence that the sector has gained in national development programmes. This has been supported by the formulation of a long term, normally a 5-year aquaculture strategy and plan, in some cases a commodity-specific plan, with the assistance of SPC, FAO or WorldFish. These signal the priority given to aquaculture, specifically, that investment in aquaculture projects whether social or commercial ventures, are encouraged, supported and protected.

This strategic development planning, the core of which is the prioritization of aquaculture needs and strengthening of technical support, could provide some answers, up to a point. On a broader perspective, strengthening the capacity and providing sufficient funding support to aquaculture R and D units is contingent on government and public expectation of the role of aquaculture in providing economic and social benefits. Aquaculture has to prove it can deliver the benefits. How? The history of Asian aquaculture development provides some lessons to go by:

- The key had been for aquaculture to prove it was worth investing more public funds into.
- It was able to do this by showing noticeable increases in production.
- It was able to nudge yield levels to a degree that policy makers noticed by using available technology, improving them, and adapting them for local application.
- As there were already technologies elsewhere, there had been no need for costly investment in developing them, only to borrow and adapt them.
- This borrowing was facilitated by technical cooperation.
- The adaptation and eventual extension of technology was done by local researchers and technicians working with farmers. The researchers, technicians and farmers had to undergo well-targeted training programmes to further improve their skills. Training was on project management, research, extension and production.
- With higher yields and better productivity, and better returns for farmers achieved, the aquaculture R and D sector could then go to government or present their case to donors for more investments in research, extension and training.
- This overall strengthening of capacity gave further boost to aquaculture development.
- Investments intensified from an assured private sector.
- Governments went a step further: they focused on some industry champions – existing businesses, both the struggling but showing much promise and the flourishing – to provide the private sector spark to the government's efforts to develop aquaculture.

Hasn't the Pacific region gone through these paces? The answer may not be simple or straightforward. It is the prompt to an interesting discussion on what the region's aquaculture sector should do next to achieve its aspirations.

Acknowledgements

The manuscript benefited from comments and suggestions of fish farmer Paul Christian Ryan, of the Vate Ocean Gardens Ltd, Efate, Republic of Vanuatu.

Annex 1

Species or group of species introduced, studied for culture and cultured in 22 Pacific Island Countries and Territories between 1937 and 2010 (species 1-44 until 1984)

1. Abalone
2. Algae (Euchema, Kappaphycus, Graciliaria, Gelidelia, Porphyra, Caulerpa, Enteromorpha)
3. Artemia
4. Aquatic macrophytes (Pistia, Hydilla,Microspora)
5. Baitfish
6. Bass
7. Brine shrimp
8. Carp (bighead, silver, grass, common)
9. Catfish (Ictalurus, Pangasius, Clarias)
10. Clam (Tridacna and Hippopus sp.)
11. Cockle
12. Common mojarra
13. Crab
14. Crocodile
15. Dolphin fish
16. Eel
17. Gourami
18. Herring
19. Jack
20. Lobster
21. Milkfish
22. Molly (Poecilia. mexicana)
23. Mosquito fish (Gambusia sp)
24. Mullet
25. Murrel
26. Mussel (Perna viridis)
27. Perch (Silver, Golden and Estuarine)
28. Oyster (Crassostrea, Ostrea, Saccostrea)
29. Pearl (Pinctada margaritifera, P. maxima, Pteria penguin)
30. Porgy
31. Prawn (M. rosenbergii and M. lar)
32. Rabbitfish (S.canaliculatus, S.argenteus, S.lineatus, S.fuscescens, S. vermiculatus, etc)
33. Scad (Carangids)
34. Scat (Scatophagus sp)
35. Shrimp (*P. monodon, P. japonicus, P. stylirostris, P. merguiensis, P. indicus*)
36. Sponge
37. Tarpon
38. Tawes (Javanese carp, Puntius)
39. Tilapia (Mossambique, Nile)
40. Tor
41. Trochus
42. Trout
43. Turtle
44. Yellowtail
45. Corals (soft and hard)
46. Live rock
47. Grouper
48. Seacucumber
49. Algae: Mozuku seaweed

SECTION B

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A country report highlights the strategic, management and technical lessons. The basis of these are a review of the national management framework for aquaculture development and an assessment of the factors associated with the success or failure of an aquaculture project or enterprise, using the feasibility screen explained in Annex 3 of Section 1. This approach tries to identify the influences of policy, market, institutional capacities and technology on aquaculture initiatives. The first seven countries are arranged chronologically according to the mission's visit between May and September 2010. Cook Islands was the subject of a review by the same Consultant on 5-24 July 2009 under the TCP/CKI/3201 project (Aquaculture Development) in Cook Islands.

Country 1

Republic of Palau
06-11 May 2010

I. Introduction

At the time of the mission, two key policy documents had been drafted by the government and national fishery stakeholders with technical assistance from FAO, namely, the comprehensive fisheries policy, the new fisheries legislation i.e. fishery and marine resources act, and the national aquaculture strategy and development plan, which would be incorporated into the fisheries law. The fishery legislation was awaiting enactment. Two other documents relevant to aquaculture development awaiting adoption were the Quarantine Strategy and Development Plan and the Code of Conduct for Responsible Aquaculture for Palau.

Aquaculture gained priority attention from government and private sector for much the same reasons as those of other Pacific Island countries: as an alternative livelihood, for income generation, demand from the tourist trade, export potential, and reduction of pressure on the declining coastal or inshore fishery resources. Food security came to the forefront fairly recently. The public sector - central and state governments - had largely led the development of aquaculture since 1970, although recently the clam aquaculture sector had formed an association to increase the role of farmers, and a private firm has established a marine cage aquaculture farm.

The primary government agency that manages the development of the aquaculture sector is the Bureau of Marine Resources. Its record of success includes the R&D impetus it gave to the commercial scale growing of hard and soft corals, which the commercial sector has continued. Another positive is the successful propagation of seed of several important giant clam species that are provided to communities for re-seeding of reef populations and for on-growing into aquarium-size clams for export. There is significant government assistance to growers. The success of reseeding has not been clearly demonstrated but the culture of clams for the aquarium trade has been sustained, indicating commercial viability. Other aquaculture species that have been developed with varying degrees of success are milkfish, grouper, rabbitfish, giant freshwater prawn and mangrove crab.

A review of the marine resources subsector strategy (in 2007) noted two important actions to develop the aquaculture sector: (a) for research and development to be done in collaboration with the private sector and for the private sector to carry on the upscaling of a pilot project to commercial scale and (b) to abandon the development of species based solely on their biological attributes in favour of an integrated approach. Current activities among the BMR, the Palau Community College, the state government of Ngatpang, and the private sector have taken some aspects of these recommendations. The status of these initiatives was reviewed by the mission. Their impacts on the development of a species into an aquaculture commodity were also assessed.

II. Background information

Introduced in Palau over 30 years ago, aquaculture has recently received priority in government development policies[1]. Since the 1970's, the farming of several species have been tried and some adopted, but the aquaculture industry is still in its infancy. There have been several successes in the hatchery of clams, corals and milkfish. Several species show promising results such as mangrove crabs, siganid, and grouper.

Palau is recognized as the first country to succeed in the mass production of giant clams during the 1970's. Several species are being produced by the Bureau of Marine Resources (BMR), planted out and farmed in coastal areas around the country for food and export as an aquarium species. Juvenile clams

[1]The draft National Aquaculture Development Strategy (FAO 2009) is cited for this background information on Palau aquaculture with some updating from the findings of the mission.

have been exported to fulfil demand for ornamental species in the US and Europe. The Palau Aquaculture Clam Association (PACA) has been organized for further development of clam farming in Palau. The plan is for the PACA to take over the hatchery functions of the Palau Mariculture Demonstration Center (PMDC). The recent CITES listing poses special challenges to international trade for giant clam. Nonetheless, the market for aquarium species of giant clam continues to grow, albeit with worries of eventual saturation and competition from Asia (Teitelbaum, pers comm.).

Milkfish farming has a long tradition in some states of Palau. There are traditional extensive milkfish ponds found around the country and Milkfish farming using fry from the wild has been practised by private entrepreneurs and State governments over several years. Much of the seed has recently been imported from Taiwan although efforts have been initiated to develop milkfish broodstock to spawn them in captivity and produce seed for local farming. The main operating milkfish farm at present is in Ngatpang State, where a State government farm is in operation producing fish for local consumption.

A private farm, owned by a local business complex was recently established; it is a cage culture operation and includes milkfish and other species particularly grouper and siganid (rabbitfish). Both state and private farms now plan to produce milkfish for food and bait. A multi-species hatchery established under the Cooperative Research and Extension programme of the Palau Community College has begun trial operations and will initially focus on milkfish, groupers and rabbitfish. It also plans to domesticate other potential marine species. Recent attempts on grouper fingerling production at the Bureau of Marine Resources hatchery in collaboration with PCC-CRE have been successful. Two pilot cage farms have availed of the hatchery-bred fingerlings of tiger grouper (*Epinephelus fuscoguttatus*) and coral grouper (*Plectropomus* species) for preliminary grow-out trials with the aim of targeting live fish markets in East and Southeast Asia. Growing interest in grouper farming has potential to build on successes in hatchery production and pilot farms, and although the local market is limited, export markets for high value live fish are available.

Rabbitfish has a history of being a preferred fish among the Micronesian people and efforts are now being undertaken by PCC-Center for Research and Extension and the private fish farm to develop and establish the seed production and grow-out techniques. Milkfish demand is likely to continue to rise, providing opportunities to expand its culture for the domestic market as a substitute for imported milkfish and bait for tuna fishing. Local demand and added value has been improved with the introduction of de-boning the fish through an FAO technical assistance.

Crustacean farming includes some experience with pond culture of shrimp and pen culture of mangrove crabs in mangrove areas in Ngatpang State, producing these for the local market. There are plans to expand shrimp farming using imported post-larvae of white-leg shrimp (*Litopenaeus vannamei*) from certified hatcheries in Guam.

These experiences demonstrate that aquaculture can be successful in Palau, responding to demand in local and export markets, and provide a baseline of experiences for further development of the sector. Palauan companies and overseas investors have shown interest in investing in aquaculture enterprises. Production and marketing opportunities exist for several aquaculture commodities within the country, although each faces various challenges.

In this regard, the workshop to draft the National Aquaculture Development Strategy identified the strengths, weaknesses, opportunities and threats to aquaculture development. These provide the context to the analysis of the feasibility issues related to the status of the species that have been developed or are being developed for aquaculture.

Strengths:
- Positive government support for aquaculture
- Generally clean environment and green image
- Apparent freedom from many aquatic animal diseases

Opportunities:
- Growing domestic demand for fish and other aquatic products
- Markets and demand in neighboring countries
- Possibilities to exploit markets for higher value niche products

Weaknesses:
- Cost of production reduces ability to compete in large commodity markets (e.g. milkfish, shrimp)
- Minimum economically viable quantity of production vs. demand
- Labor skills and costs
- Lack of existing infrastructure and services for aquaculture

Threats:
- Competition from neighboring islands/countries for export markets
- Access to input resources and economical sourcing and production
- Weak institutional support

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indications for the mission to follow up.
2. Reports relevant to fisheries and aquaculture in the Palau and the Micronesian area.
3. Face to face interviews with key informants; these included policy, management, and technical personnel in government agencies (national and state), academic institution i.e. the Palau Community College, NGOs, local government officials, and private entrepreneurs. The list of persons met is on Annex 1.
4. Visit to projects, farms and hatcheries and interviews with the managers, technicians or caretakers.

IV. Findings

This mission report provides indicative and broad findings. The findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. Overall development policy is geared to food security and income generation
2. Strong environmental protection and resource conservation measures with the Environmental Quality Protection Board and the Department of Conservation and Law Enforcement but with no provision that relates to aquaculture management
3. Heavy state (national government) subsidy to giant clam farming
4. State (state government)-initiated aquaculture development with little participation of the private sector
5. Encouragement of private initiatives but with unclear incentives
6. The Code of Conduct for Responsible Fisheries as the template for a sustainable aquaculture development; National Aquaculture Strategy being finalised

2. Aquaculture initiatives and impacts

The species (and systems) that have been initiated and a brief description of their results are described in the table below.

1.	Giant clam – probably the most successful and sustained aquaculture system, with continuing government support; aquarium trade provides the commercial impetus
2.	Milkfish in ponds and cages – technology and expertise from the SEAFDEC Aquaculture Department based in the Philippines provided the impetus for the milkfish aquaculture, carried on further with FAO technical assistance in culture and processing. A state government (Ngatpang State) followed by a commercial enterprise (NECO) have expanded into cage culture of milkfish following the success of pond culture and the potential market for the fish as food and bait; broodstock are now being developed in the cages of both farms. The plan is to provide the Palau Community College Multi-species Hatchery some of the broodstock for seed production. Currently milkfish fry are sourced from the wild and being imported mainly from Taiwan Province of China.
3.	Grouper – Natural spawning has been achieved for three species but survival rate of fry has been abysmally low. This remains the bottleneck for commercialization. One of the staff in charge of this work has been trained under NACA's Regional Mariculture R and D Programme in grouper hatchery and culture training course in Situbondo Indonesia. In recent years, PCC has been working in collaboration with the Bureau of Marine Resources on seed production of grouper and this will be continued in the new PCC Multi-species Hatchery.
4.	Siganid (rabbitfish) – culture of two species of hatchery-bred rabbitfish in cages has shown good results; seed production technology has been developed by a researcher at Palau Community College. The new Multi-species Hatchery was set up to fine tune the technology and produces more seed to support the growing interest on commercial production.
5.	Mudcrab in pens within mangrove - a commercial venture in Ngatpang State is providing a good example of a mangrove friendly grow out system; source of crablets for grow-out is a constraint. Regulation, which prohibits catching of crabs less that are 6 inches in carapace width precludes catching of crablets and on-growing them in confinement. PCC has started a project on the seed production of mangrove crabs funded by the USDA.
6.	Giant freshwater prawn - the sole crop was successful, which showed that the species can be grown commercially, but interest waned after pilot production ponds developed and built by the BMR were taken back by the land owner who then could not duplicate initial success.
7.	Marine shrimp – early efforts showed some promise; no follow up as yet.
8.	Sea cucumber – a Korean technician-operated seed production project using facilities of the Bureau of Marine Resources is successfully producing seed for stock enhancement.

3. Lessons

The lessons from the previous and current aquaculture initiatives are based on the analysis of the important farming system/species using a analytical framework that focuses on the feasibility issues of farming or producing the species, namely biological, technical, economic and social. This analytical framework has been applied to the screening of a potential species/ farming system before it is recommended for further pilot test in a wider domain or for adoption by farmers. It is applied here to systematically determine the issues attendant to the culture of a species. (The logic of this scheme appears as Annex 3 of the Synthesis).

The analysis for the important and potential species appears as Annex 2 with milkfish as an illustrative example. The other species are giant clam, siganid, grouper, mangrove crab and freshwater prawn. Marine shrimp and sea cucumber are not analysed but some lessons from the ongoing work on sea cucumber seed production at BMR are cited.

3.1. General lessons

The general lessons that have stood as keys to success in the development and adoption of a species for aquaculture include:

3.1.1. Government initiative to borrow and adapt already known technology, rather than "reinventing the wheel". The example is milkfish aquaculture which has shown that the strategy can quickly and economically start up local aquaculture development. The experience in Palau also argues for importing expertise, if affordable, to help establish the culture technology. The current status underlines the need to develop local expertise for management and technical work for the longer term. The perception of a limited work opportunity in the sector and the near complete reliance on expatriate workers may be influential.

3.1.2. Institutional cooperation among the government fishery agency (BMR), the scientific and R and D community (Palau Community College Cooperative Research and Extension), Environmental Quality Protection Board (EQPB), conservation and legal enforcement authority, and the private sector would facilitate the solution of technical and economic problems and assure an environmentally friendly aquaculture sector; stakeholder consultations would make conservation and environmental regulations a facilitator rather than a barrier to sustainable aquaculture development, as it is being perceived now by investors. Regulations that are proposed and those that are in place could draw technical guidance from the CCRF and the concept of EAA.

3.1.3. Species that meet food security and higher income would have a better acceptance, but a species (and farming system) that can provide households a better income (rather than only food security by providing food to the farm household) would rate a higher priority for development and likely a better adoption.

3.1.4. The milkfish case points to the importance of a local champion - be it a person or an institution - in helping drive the development of an aquaculture species or commodity industry.

3.2. Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the species in Annex 2.

3.2.1. Strategic:

- Milkfish: while milkfish has been cultured traditionally and there is a significant wild seed resource that might have sustained its expanded aquaculture, it was the importation of technology and expertise that kick-started its farming.
- Giant clam: two areas of cost-benefit analyses, namely, (a) cost and return and net social benefit would better inform the privatization plan of government. Cost and returns would be needed by investors, (b) and an assessment of social benefits from the subsidies would guide further government investments in R&D and approach to its development.
- It is desirable to develop a strategic and management plan for each species as these would have different technical requirements and marketing strategies. However a unified strategic and management plan for all farmed species and those planned to be developed would enable (i) a better allocation of technical and material resources and (ii) identification of similar or related production and marketing issues across species that government and private sector can address.

3.2.2. Management

- The environment and conservation regulations have been very effective in protecting the coastal resources. On the other hand the rules and regulations are seen by the private sector as a barrier rather than a management mechanism or facilitator to aquaculture development. The conservation and legal enforcement agency however is keen to cooperate with BMR in developing measures that would balance the conservation and development objectives of coastal resources management.

- Giant clam: privatization of the industry is a desirable action. The planned takeover of the giant clam hatchery and nursery facilities by the PACA should be reinforced by government providing the PACA members further training and technical advice on better farming, better management practices and more effective marketing. The government and PACA could cooperate in developing the export market specifically establishing global market links.
- Milkfish: Government (national and state), scientific and academic (BMR and PCC- CRE), and private enterprise are engaged in or have initiated activities that address various constraints. Some joint efforts have been initiated among BMR, the state farm in Ngatpang, NECO and PCC-CRE particularly in broodstock development and seed production. This collaborative mode needs to be maintained in all future efforts and expanded to include the private sector, other states and the conservation and legal enforcement agency.

3.2.3. Technical:

- Hatchery technology: the mission was informed that other state governments are keen to set up hatcheries in their states (they have borrowed the building plan for the PCC CRE Multispecies Hatchery with the intent to set up a similar, if different scale, in their states as one that has recently been established by PCC); this will require a massive and urgent training of hatchery operators, but even more urgent is to rationalize the establishment and purposes of the hatcheries.
- Milkfish: the technical lessons from the milkfish initiative are that a package of technology bundled with technical expertise was acquired and that there is scope for value addition to cater to the local market. Diversifying into the bait market might help improve the economic performance of farms with a faster crop turnover, production of small size fish on primary productivity or with less supplementary fish food.
- Mudcrab in mangrove: the sole crab farm can serve as a demonstration farm but there is need to establish a seed production project especially if the current regulation on crab size for collection from the wild is not amended to allow smaller size juveniles. Hatchery technology is available from SEAFDEC AQD and other institutions but it is far from perfected for mangrove crabs.
- Grouper and siganid: broodstock development and seed production are always the most difficult biological bottlenecks to a commercial scale grouper culture industry. The manpower that has the technical skills to solve the problems is scarce in Palau - one in BMR, one in PCC-CRE and one in the private sector. The BMR staff have been trained in a regional course under the NACA marine finfish programme and has done some marginal improvements in broodstock development and spawning. A collaborative work could improve the technical resource base for this work.
- Giant clam: the success of the giant clam seed production has not been translated into success in seeding and enhancement. The success of farming for the aquarium trade need not be a barrier to the re-seeding goal, but the more immediate and visible reward from farming does tend to make it more attractive to farmers and communities.
- Freshwater prawn: The lack of any more follow up on what appeared to be a successful pilot project to farm giant freshwater prawn is probably more a social problem than economic or technical. What transpired was something that a hazard identification and risk assessment would likely have failed to spot. Nevertheless, the more fundamental legal and social issue of land ownership needs to be considered in aquaculture development.

V. Conclusions

The review reiterates the recommendation of previous studies to enact the fisheries law, complete the comprehensive fisheries policy and finalize the national aquaculture strategy and development plan, which at this point has undergone extensive stakeholders review.

A strategic approach to species development for candidate species has now been made more feasible with the establishment of a multipurpose hatchery and the presence of a state and a private farm for on-farm trials. The critical expertise needed for this strategic approach is economics and social science. These expertises are crucial for the economic and social assessment of feasibility and the upscaling of technology and its promotion for adoption by smaller farmers.

At this stage, none of the species being cultured are near the stage where it might be necessary to assess market demand and develop a strategy to prevent market glut from too much production. Nonetheless, the milkfish market should be studied for the purpose of working out a crop cycle programme so that harvests are timed when wild fish may be scarce and protein food available need to be complemented with cultured fish. This market study should also cover the timing and volume of bait demand so that stocking of ponds and cages for bait and for foodfish production can be programmed to take advantage of the best price.

As aquaculture is given more support and attracting private sector investment, it would be timely now to develop better management practice guidelines for the culture of at least milkfish, crab and probably siganid and grouper (as these are now being tried in cages using wild seed, or likely imported seed. With imports of live fish, it is crucial to strengthen the quarantine regulations with a risk analysis protocol.

Finally, the technical development of all the species being cultured or developed for culture owe much to technology being acquired from elsewhere. There is no need to belabour the point that technical cooperation is beneficial. This is particularly important in a regional grouping where the priority species are similar, the local resources are limited, and the R&D and economic issues are similar. Cooperation can include nearby sources of technology and expertise such as Guam, Hawaii, Japan, Republic of Korea, the Philippines and Taiwan Province of China.

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Annex 1

Persons Met in the Republic of Palau

1. Harry Fritz, Minister, Natural Resources, Environment and Tourism
2. Shallum Etpison, President, NECO Group
3. Ms Nannette Malsol, Acting Director, Bureau of Marine Resources (BMR)
4. Theo Isamu, Former Director, BMR
5. Harvey Renguul, Fisheries Specialist (Giant Clam) bmr@palau.net
6. Ms Percy Rechellul, Fisheries Specialist (Finfish) bmr@palau.net
7. Ms Lora Demei, Fisheries Specialist, BMR
8. Ms Helena Rebelkuul, Administrative Officer , Bureau of Marine Resources Ministry of Natural Resources, Environment, and Tourism Tel: (680) 767-3125 / Fax: (680) 767-3380
9. Eric Basco, Aquaculture Specialist, NECO Group je_basco@yahoo.com
10. Thomas Taro, VP Cooperative Research and Extension, Palau Community College
11. Miguel de los Santos, Researcher and Aquaculturist, CRE, PCC mdelo_29@yahoo.com
12. Ms Sisca Otong, Executive Officer, Ngatpang Aquaculture Project
13. Valentino Emesiochel, Manager, Ngatpang State Aquaculture Project
14. Romer Ticar, Chief Technician, Ngatpang State Aquaculture Project
15. Ronny Ticar, Technician, Ngatpang State Aquaculture Project
16. Ms Ilebrang U. Olkeril, Director Department of Conservation and Law Enforcement, Koror State Government
17. Ramon Rechebei, Ambassador to the Philippines, Non-Resident Ambassador to Indonesia and Vietnam; Former Adviser, Micronesia Marine Authority
18. Gibson Kanai, Member of the House of Delegates and Floor Leader, Palau National Congress

Annex 2

Feasibility issues of selected species and their farming systems, Palau

1. Giant clam

Enablers/*constraint*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Seed production and culture of giant clam are well known and the technology is transferable.			Government re-stocking program along with promotion for farming has sustained the resource.
Research	The Palau Mariculture Demonstration Center (PMDC) has successfully cultured all Palauan endemic species of giant clams for over two decades and can produce all species on a semi-commercial production basis.		*Manpower for research on the economics and competitiveness of the species is not available*	
Extension		Government, through BMR's Palau Mariculture Development Centre (PMDC) has continued to provide material and technical advice to farmers. *Manpower shortage for sustained extension service.*		
Institutional collaboration & partnerships		The Palau Aquaculture Clam Association has been an important institution in helping sustain production and trade	BMR and Bureau of Economic Development: BMR provides 1 yr old clams for farmers to grow out and technical advice to farmers; BED through a Taiwanese grant provides funds for materials; assists in marketing; and provides advice to PACA on economic opportunities and private sector funding sources	
Market development		*CITES listing of giant clam is constraining trade*		
Keys to success	A sustained market in aquarium species.			
Key Constraint	*Government's plan to privatize the giant clam sector, including seed production, is not compatible with the continuing subsidization of giant clam farmers.*			

2. Milkfish

Enablers/ constraints	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/ regulations	Milkfish is a naturally occurring species in Palau waters; waters are conducive to cage culture. Government has allowed and now encourages its culture in coastal waters, which as of now are pristine. Environmental regulations and conservation laws protect the coastal waters from pollution including pollution from aquaculture to maintain water quality.	Government's initiative to import technical expertise; a local market exists; FAO assistance in post-harvest processing to add value to the fresh product. Importation is allowed for seed and feed from Taiwan.		The presence of a sizable population of traditionally milkfish eating people (i.e. Filipinos) has boosted market demand.
Research	Broodstock development, artificial spawning, hatchery and culture of milkfish have been developed elsewhere (SEAFDEC AQD in the Philippines) and can be transferred to Palau	*Local seed sources are plentiful but have not been assessed and remain unexploited.* PCC-CRE has an experienced research staff in the seed production of marine finfishes including milkfish. A multi-species hatchery is available to initiate the seed production trials once broodstock are ready to spawn.	*s of now, cost and return studies and competitiveness analysis have been constrained by the lack of an R&D programme and expertise.*	
Extension		Private sector has adopted milkfish farming; NECO has set up a floating cage culture farm in a lagoon near Koror. PCC-CRE is tasked to extend the technology to local farmers		
Institutional collaboration & partnerships	NECO, Ngatpang State fish farm and Palau Community College are collaborating in broodstock development and seed production	PCC-CRE, and BMR Staff have the technical capability in seed production of finfish including the milkfish		

Market development		It is a preferred fish in Palau and restaurants have included it in their menus; the deboned product form and quality and safety attributes have improved consumer preference.	Relatively high price of fresh, and deboned, minimally processed milkfish in the local market. The market for tuna bait is significant and the two farms have initiated plans to produce bait-size fish. *An assessment of the market needs, remains to be carried out*	
Key to success	Technology and expertise for seed production, culture and processing brought into the country. A limited but economically attractive local market.			
Key constraint	*Expansion of farming to other states is constrained by lack of local expertise.*			

3. Siganid (rabbitfish)

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Government's conservation policy has helped maintain the natural population and the quality of coastal waters	R&D had been previously carried out by the former Marine Resources Authority. In line with the programme to develop milkfish, the government has encouraged the expatriate technical expertise to work on siganid.		A traditional preference for the fish in the Northern Pacific.
Research	R&D from PCC has developed broodstock development, seed production and culture technology for two most popular siganid species. (*Siganus fuscescens* and *S. lineatus*) in Palau.	PCC Researcher and Staff are capable of producing hatchery-bred siganids in a commercial scale.	Study on the economic analysis in the grow-out of siganids in tanks, ponds and cages is necessary	
Extension				
Institutional collaboration & partnerships	PCC's CRE, BMR and NECO have initiated work on hatchery and grow-out trials			
Market development				
Key to success	The technology in seed production is available locally. A large potential market locally and in other islands; the high price and high consumer preference for the fish.			
Key constraint	*The slow growth of the fish would be a constraint to adoption by small farmers.*			

4. Grouper

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Government's conservation policy has helped maintain the natural population and the quality of coastal waters.	BMR established a grouper breeding programme allocated a hatchery facility for the programme.	*There is no focused programme to develop grouper aquaculture for local and export market; no market studies.*	
Research	R and D from elsewhere has developed broodstock development, seed production and culture technology for the same species in the BMR's hatchery. Only few numbers of broodstock and spawners are available. Need to collect some more.	*R and D expertise needs strengthening. Hatchery facility appeared to need some improvement.* *Parasite infestation is a problem to groupers in cage culture.* BMR and PCC-CRE staff are capable of conducting seed production trials in the hatchery.		
Extension		A staff of BMR was trained in Indonesia under NACA's Asia-Pacific Marine Finfish Network R and D Programme	NECO cage farm has begun growing groupers collected from the wild.	
Institutional collaboration & partnerships	PCC's CRE, BMR and NECO have initiated work on hatchery and culture.			
Market development				
Key to success	Collection of more broodstock and spawners from the wild to provide steady supply of eggs for larval rearing trials.			
Key constraint	*Spawning has been achieved but survival rate is extremely low to guarantee a sufficient as well as reliable seed supply;*			

5. Mudcrab (mangrove crab)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Regulation on mud crab capture (i.e. not less than 6-in in carapace width should not be captured for culture or direct sale) protects the resource. Strict mangrove conservation regulations protect the habitat.	The same regulation however tends to limit the options of crab on-growers. (one of two crab farms established was closed because it was found using smaller sized wild crablets. *Feed will likely be a constraint and the only source now is farm made feed with trash fish as component (tuna trimmings).*		
Research	Seed production/ hatchery technology has been developed in many institutions including AQD SEAFDEC.	PCC-CRE has recently started conducting research on the seed production of mangrove crabs. Preliminary runs are being undertaken. The hatchery is now ready for conducting this work.		
Extension		Technicians from the Philippines are operating a crab farm established within a mangrove applying technology that is well known in the Phil, Indonesia and Vietnam.		
Institutional collaboration & partnerships	Private farm supplies PCC-CRE the broodstock requirements in seed production research			
Market development			An institutional local market (hotel and restaurants) is sustaining the lone crab farm in Palau. *No assessment has been done for expanding the local market or for export.*	
Key to success	Technology and expertise available and brought into the country; local market is good and product price is attractive, Trained staff to undertake seed production trials is needed.			
Key constraint	*Constraint to expansion is lack of local expertise and as of now a reliable seed supply.*			

6. Giant freshwater prawn

Enablers/*constrain*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulation				
Research	Local species available and the technology to breed and culture the species is well-known			
Extension			*Commercialization did not take off because of loss of interest from government and with private farmer unable to duplicate initial success achieved by BMR.*	*Landowner of the pilot project site terminated relations with BMR. Did not achieve the same success in his commercial attempts.*
Institutional collaboration & partnerships				
Market development				
Key to success	Technology and local species are available			
Key constraints	*Lack of follow up R and D to initial success.*			

Country 2

Marshall Islands
12-17 May

I. Introduction

The goals of fisheries development in the Republic of the Marshall Islands (RMI) are to improve economic benefits from the fisheries sector within sustainable limits; strengthen institutional capacity to facilitate the responsible development and management of fisheries resources; support responsible private sector enterprise as the primary vehicle for fisheries development and; support the preservation of coastal, reef, and lagoon resources for nutrition, food security, and small-scale sustainable income earning opportunities for the community. The objectives of *nutrition, food security, and small-scale sustainable income earning opportunities* guide mariculture development in the outer islands. The National Fisheries Policy (of 1997) recognizes that culture fisheries demonstrate potential to make a valuable contribution to economic development[2].

The standard of living in the outer islands (all areas outside of Majuro) has been steadily declining due to expanding population and the fall in world prices of the major export, copra, a primary source of cash income of atoll communities. Living marine resources in both Majuro and the outer islands have long been exploited for subsistence purposes. Today both food security and the ability to derive local income from capture fisheries are at risk because increasing pressure on marine resources from increased local and foreign commercial fishing effort and other environmental stressors.

II. Background information

Mariculture in RMI has two features that need to be considered for its technical development: (I) there has been an emphasis on using locally occurring species which means that comparatively less is known about the basic biology, culture, and ecology of these species than popular species such as tilapia or milkfish, which have a long history of domestication; (ii) all mariculture in the RMI relies heavily on wild stock at some point in the life cycle and is conducted in sensitive habitats. Nonetheless, the biological and economic feasibility of large-scale, commercial mariculture has been demonstrated by the long-term and profitable existence of two companies based in Majuro, which are producing black pearls, giant clams, and soft and hard corals.

Most aquaculture efforts have focused on marine invertebrates such as black-lip pearl oysters, giant clams, trochus, and corals. With the exception of trochus, these are being grown commercially in the RMI. The emphasis on invertebrates is primarily due to their high value and low technology rearing methods, and because these particular species do not require formulated feeds as adults. Hatchery production of these species is also simpler than marine fishes. The absence of wetlands (other than coral reefs and some mangroves) rules out fresh or brackish water aquaculture.

Attempts to develop finfish for culture are recent and limited to grouper and rabbitfish with as yet limited results. The long term objective is to supplement an already decreasing near shore fishery even as the population in the major islands such as Majuro and Ebeye are increasing because of migration from the outer islands the increasing number of workers from Asia and visiting fisherfolk. These and the increasing price of fish present an incentive for mariculture investments.

The National Fisheries Policy (1997a) and the National Fisheries Development Plan (1997b) contain provisions pertaining to mariculture. The National Fisheries Policy (1997) sets out strategic direction for the development of industrial, island and atoll, and culture fisheries. A draft updated national policy is awaiting enactment.

[2]This introduction and the background information are largely based on "Policies and Priority Actions for Sustainable Mariculture Development in the Republic of the Marshall Islands, 2005" prepared by the Mariculture Working Group, and approved in principle by the MMRA Board of Director in September 2004.

The Marshall Islands Marine Resources Authority has the mandate to manage and develop the fisheries resources. Among its functions are to carry out and encourage the private sector, other institutions and donors to conduct or support applied research and culture fisheries development activities; source technical and advisory support for community groups or local enterprises to establish commercial activities based on the culture or enhancement of marine resources found in the RMI. Safeguards to the overexploitation or degradation of the marine resources are also in place.

MIMRA has recently drafted a biosecurity programme with FAO assistance. There is a strong environmental regulation owing to the unique and fragile nature of the country's terrestrial and marine environments. To ensure that investment activities do not damage the fragile coastal ecosystem, the Government requires an environmental impact assessment (EIA) of all new development projects that may have a significant impact on the environment. Investors notify the Environmental Protection Agency (EPA) before starting any development to determine if an EIA is necessary.

The workshop on mariculture in 2004 identified the issues as well as developed a SWOT analysis for the sector. Some of these remain relevant and the broad statement of strategy issues is cited herewith for background information.

- A persistent problem is the lack of financial resources and trained staff for the promotion of mariculture and to fulfil the roles and responsibilities of government agencies. The solution seen is a directed and concerted effort at fundraising with external donor organizations.
- Restocking of threatened and depleted species (e.g. *T. gigas* species) in parallel with Marine Protected Areas in community-based fisheries management planning was an area repeatedly stressed as urgent. The identified need is a pilot program to test the effectiveness of restocking efforts. It would also address Issues related to using adults or juveniles for restocking.
- Facilities were seen as in poor condition, necessary tools and equipment are lacking and different public facilities were not coordinating sufficiently. The need was felt for improved coordination and planning among the organizations operating public facilities (such as MIMRA, Land Grant, and CMI). Commercial operations that at times rely on production on public facilities needed to be actively involved in the review of needs, in planning and in development and implementation of projects.
- Institutional coordination was crucial in the development and mariculture regulations, restocking, and protected area management, particularly the clarification of institutional mandates. A common vision for mariculture development needs to be shared by all the institutions. Specific permitting issues such as EIAs can be developed once effective institutional arrangements are in place.
- Community awareness, public education and local involvement in mariculture emerged as a theme of particular interest. Curriculum at all levels of education in the RMI need to incorporate mariculture. It was suggested that the successful High School education program (e.g. Jaluit) be continued and expanded to other atolls. Economic development and career planning workshops can be used to stimulate public awareness of mariculture.
- Finding ways to provide outer island benefits from mariculture and maximizing RMI income and employment benefits was a great concern. It was pointed out for example that public hatcheries that sell product to private companies need to benefit people in the atoll where the product is produced, not only the national government. Strategies for expanding local benefits to outer islands need to be developed. The advantages and disadvantages of foreign ownership of business also need to be considered.
- Security of land tenure arrangements and clarity on land and water availability for mariculture are critical for long-term business planning and smooth operations. There is a need for further dialogue to clarify land tenure issues and to find solutions to land use issues. Three parties usually have to sign a land lease for any development: the customary owners, the government, and the lessee.
- Despite the small number of commercial mariculture businesses in operation, they play a major role in guiding the development of the industry. More formal coordination and planning mechanisms among the private sector (such as an industry association) may be beneficial, for

example in providing leadership on a vision for mariculture growth, promoting voluntary best management practices, and providing a single business voice to lobby for sustainable mariculture development both in RMI and externally. Such an association can contribute to developing Mariculture and Aquaculture Management standards and better practices.

- Links can be developed between mariculture and the tourist industry to further increase its contribution to the economy especially those of the outer islands.

The analysis informed the formulation of vision for sustainable mariculture development that consists of the following aspirations:

- Education and awareness that empowers communities
- Links to ecosystem management, community-based fisheries, and preservation of biodiversity
- Outer island production that links with operations and transportation systems in Majuro
- Food security and gender equality
- Community-based and culturally-appropriate outer island development
- Income generation leading to reduced dependency on government programs
- Availability of start-up capital for reputable and profitable businesses that increase exports in a globally competitive market

This vision statement has been the broad guideline to mariculture development in RMI.

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indicators for the mission to follow up; it was accomplished in varying state of completion by RMI respondents.
2. Reports relevant to fisheries and aquaculture in the countries
3. Face to face interviews with key informants; these included policy, management, and technical personnel in government agencies, College of the Marshall Islands, an NGO, heads of three local governments, and private entrepreneurs. The list of persons met appears as Annex 1.
4. Visit to projects, farms and hatcheries of government and a private firm.

IV. Findings

This report builds on and tries to add value to the reviews and recommendations that have been made for mariculture development in the RMI by focusing on the specific feasibility issues of important and potentially important species and their farming systems. In line with the terms of reference, the findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. Overall development policy is geared to food security, income generation and poverty alleviation; atoll communities look to aquaculture as a source of food, a buffer against dwindling marine fishery resources, and to improve income in light of generally decreasing returns from producing copra, the major agriculture export.
2. Encouragement of local government initiatives and private investments.
3. A strong emphasis and support from government for giant clam farming and coral culture, and re-stocking or enhancement of the coral reef resources under the coastal management programme.
4. CCRF and Ecosystem Approach are templates for a national strategy for sustainable aquaculture
5. Policy on aquaculture was being finalised.
6. Risk analysis being implemented on the movement and introduction of live animals.
7. Perceived lack of focus on R and D efforts in the sense that resources are being spent on what is considered too many species as well as diffused objectives of research efforts.

2. **Aquaculture initiatives and impacts**

The species that have been cultured, in various degrees of success, and a brief description of their results are described below:

1. *Giant clam* - the most successful and sustained aquaculture species; government research and demonstration has facilitated uptake by farmer groups; a private company is contributing to its farming and trade by producing baby clams for on-growing by farmers
2. *Corals* - same result as above, but confined to a private commercial venture, which produces the seed for on growing.
3. *Pearl oyster* - mixed success; good results initially of commercial ventures; technical advice was provided to farmers by government. One atoll community has natural resources and is taking advantage of this endowment; a government seed production effort is running into biological (water quality) and technical (hatchery) problems. One commercial venture suffered from a low demand; the result is it was unable to cover its production costs.
4. *Trochus* - initial efforts have not been actively followed up but plans are to resume R&D and encourage commercialization.
5. *Seaweed* (*Eucheuma* sp.) - trials faced problems of grazing from siganids and turtles; otherwise the seedling production and initial growth were successful; there has not been any effective measure found to prevent turtle predation anywhere that this is a problem, so the trials were discontinued.
6. *Grouper* - seed production remains a constraint; biological problems and technical constraints have yet to be solved by a government project assisted by foreign technical cooperation. College of Marshall Island hatchery is also working on finfish broodstock and seed production.
7. *Siganid* - same as above; some social issues as well with the loss of mature fish being developed as broodstock. The CMI hatchery is also working on the same species.

3. **Lessons**

The lessons from previous and current aquaculture initiatives are based on the analysis of the important farming system/species using an analytical framework that focuses on the feasibility issues of producing the species, namely biological, technical, economic and social. The main example is giant clam farming but lessons are also derived from the experiences with the other species/systems that include pearl oyster, siganids and grouper, and red seaweed. There are others such as trochus and corals but trochus was just being proposed for a renewed R&D programme and those on corals are closely similar to those on giant clam. The analysis appears as Annex 2.

3.1. General lessons

The general factors that come out as contributing to the success of farming a species are as follows:

3.1.1. Similar to the general situation in other Pacific Island countries, the species and farming systems that have been successful are compatible to the social and cultural lifestyles of the farming communities. Species whose culture allows more time for the farming household to take care of the many other activities seem to be preferred. For species that demand more intensive technical and management inputs, the importation of personnel could be considered as an interim arrangement while local personnel and farmers are trained.

3.1.2. The Marshall Islands pilot project on giant clam gives evidence that a total subsidy to farmers of seed and other inputs need not be made to encourage adoption. The private commercial sector has demonstrated it can carry out a large part of the activities to sustain an industry including seed production and marketing. On the other hand, the role of government in organizing farmers and providing the extension and technical advice - which a private company might not wish to undertake - remains essential. There is scope however in encouraging the private sector to eventually take up these tasks, as is done in a contract farming scheme

3.1.3. Institutional cooperation among government fishery agency, the scientific and R&D community, the environment and conservation agency, and the private sector would facilitate the solution of

technical and economic problems and assure an environmentally friendly aquaculture sector; stakeholder consultations would make conservation and environmental regulations a facilitator rather than a barrier to sustainable aquaculture development. Regulations that are proposed and those that are in place could draw some technical inspiration and guidance from the CCRF and the concept of EAA.

3.1.4. Species that address the need for food security and higher income would have a better acceptance. If a choice has to be made, a species (and farming system) that can provide households a better income would likely be given a higher priority for promotion.

3.2. Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the various species subjected to analysis in Annex 2.

3.2.1. Strategic:

- Giant clam farming and trade: income generation and a farming system that allows the farmer to conduct other priority family activities improves adoption;
- Pearl oyster: multi-stakeholder cooperation especially between government, academic (i.e. CMI land grant) sector, private entrepreneurs and atoll community leaders would likely come up with a strategy and plan for developing the industry that reconciles their needs and addresses common objectives;
- Grouper and siganid: risk assessment and feasibility assessment based on experiences in other countries would identify and avoid potential biological and technical problems, and technology available from other countries could have increased the chances for a technically feasible project.

3.2.2. Management:

- Prioritization of needs and using these to inform a sector strategic and management plan would bring more focus on R&D. It also underlines the need for self-management to reduce dependence on an often strained and under-resourced government fishery service.
- The business model developed for the giant clam - i.e. commercial firm-small farmers technical and marketing arrangement - could be a workable model for other export-oriented species; it reduces government's role in these activities and enables it to focus on its role as facilitator of R&D and private sector investments, and as regulator.

3.2.3. Technical:

- Grouper, seabass and pearl oyster: a concerted effort by both government and academic R&D institutions would facilitate the solution of the biological and technical constraints;
- Giant clam: training of farmers has clearly resulted in better and more profitable farming; the scheme that combines financial reward and social recognition is shown as a strong incentive for farmer adoption and farming responsibly.

V. Conclusions

The potential contribution of aquaculture to the economy of RMI and especially to the atoll communities has been generally acknowledged, but these have not been measured. Nonetheless, the benefits to farmers and exporters from giant clam and coral farming and export and from pearl oyster culture have been significant. Farmers in pilot projects have earned good income from clam and coral farming, and private investors have been attracted into pearl oyster farming. As to the food fish, the decreasing or stagnant coastal fishery resource argues for research investments into the culture of such preferred species as grouper and siganid. The same can be suggested for trochus, which can be revived as a good source of income from its export but whose natural fishery has been depleted. In sum there is a strong economic and social argument for focusing R&D efforts and investments into these aforementioned species.

As to investment by government and donor assistance, three issues arise: (i) cost and benefit of the R&D investments, particularly a re-examination of activities that border on what could be unacceptable

subsidy and (ii) the need to focus R&D efforts on a fewer species and key feasibility issues; fewer priority species based on their economic and social importance would concentrate expertise and resources and identifying the key constraints to feasibility would avoid wasting resources on trying to solve the wrong problem; and (iii) enhancing cooperation in R&D. Cooperation among local institutions would increase the impact of their pooled manpower and material resources, avoid duplicating and therefore wasting resources, and build on each others' efforts and results. Cooperation should be expanded to the sub-regional and regional levels for a greater impact of resources and results.

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Annex 1

Persons Met in the Republic of Marshall Islands

1. Mattlan Zachhras, Minister for Resources and Development; Chairman, Board of Directors, Marshall Islands Marine Resources Authority
2. Ms Florence Edwards, MIMRA Chief of Coastal and Community Affairs fedwards@mimra.com
3. Ms Melba White, MIMRA mwhite@mimra.com
4. Ms Rebecca Lorennij, Deputy Secretary, Min of Resources and Development
5. Danny Wase, Former Director MIMRA
6. James Capelle, Mayor, Likiep Atoll
7. James Matayoshi, Mayor, Rongelap Atoll
8. Clarence Luther, Mayor of Namdrik Atoll
9. Don Hess, Vice President, College of Marshall Islands (CMI)
10. Carl S. Hacker, VP College and Community Resource Development, CMI
11. Julius Lucky, Aquaculture Specialist, CMI Land Grant
12. Albert Dai, Aquaculture Specialist, IFDC Taiwan/MIMRA Finfish Project
13. Technician, Marshall Island Mariculture/ORA, Clam and Coral Hatchery
14. Ramsey Reimers, Chairman and CEO, Robert Reimers Enterprises rreadmin@ntamar.net
15. Michael Cheng, COO, RRE
16. Carlton Abon, Information Specialist, Marshall Island Conservation Society

Annex 2

Feasibility Issues of Selected Species and Their Farming Systems, Marshall Islands

1. Giant clam

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Government-led and encouraged local species development and introduction of other species for food and aquarium trade. Government policy to protect marine resources from over-exploitation of marine resources and ensure supply of marine ornamentals through a management and monitoring programme.	Seed production and distribution by government and private commercial firm and a buy-back scheme from farmers at prevailing market price sustains interest of farmers; government trade policy; species development and quality assurance of product are positive factors.	Trade in aquarium size giant calm and government support to the industry – to the private sector, farmers and local governments – is sustaining the economic viability of the industry.	Giant clam is a priority income- and employment-generating aquaculture activity in RMI and in many PICs.
Research	Giant clam technology for hatchery and grow-out already well established and disseminated among PICS from long running and various national efforts.	Research on seed production and farming continues to be supported by government.	Continuing studies Research on the production of food fish and aquarium species - but especially aquarium species - is sustaining the industry.	
Extension	Government promotion of clam farming among farmers has provided a good example of a viable small -farmer enterprise		A key feature of the government pilot project is that the material assistance to farmers is not a subsidy because cost of materials (seed and nets) are deducted from farmers' revenue from the sale of the crop. International promotion of the products from the Pacific islands, by commercial enterprises, governments and regional and international assistance organizations, in general is sustaining the trade in giant clam as an aquarium species.	The satellite farming project encouraged by the government on one atoll, Arno, has shown that an element of constructive competition among farmers (i.e. who is seen as producing better and earning more, and why) can improve production and economic returns of all participants.

Institutional collaboration & partnerships		Training in farm management continues to be promoted and provided by government	Enterprise management is part of the technical assistance to farmers	
Market development		The link between the commercial venture and the US market is an advantage	A multi-level collaboration in R&D and in promoting the trade commercial venture between national and municipal governments and private commercial company.	
Keys to success	The presence of a commercial venture that finds the trade in giant clam profitable; links with market for aquarium species; farmers enjoy income from growing out giant clam; government support to the aquarium trade.			
Major constraints	Transportation links and competitiveness; extension is constrained by shortage of staff and the distances between the atoll communities.			

2. Pearl oyster (Pinctada spp)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy			MIMRA Act 1997 gives the Marine Resources Authority oversight on trade of marine products including live species.	
Research	*Water quality of the lagoon where the Woja hatchery had been drawing water was thought to be unsuitable for pearl oyster spat production*	CMI's Arrak pearl oyster hatchery has been successful with spat rearing.		
Extension		Technical advice provided to pearl oyster growers in atoll communities by government. Arrack hatchery also distributes oysters for culture to the outer-islands and training interested communities on harvesting pearl oysters.		

Institutional collaboration & partnerships		CMI's Arrack hatchery also supplies oysters to other companies and projects, such as the government's Woja Pearl Oyster hatchery. R and D and expertise form collaboration among CMI, CSTDA, University of Hawaii in Hilo and the MIMRA.		
Market development			*Cannot compete with pearls from other Pacific countries*	
Keys to success	In one atoll, a natural population is occurring as a base for culture.			
Major constraints	*Market. Local technical expertise in growing and nuclear implantation is lacking. Difficult to compete with established producers in other countries.*			

3. Siganid (rabbitfish) spp and grouper spp.

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Coastal fisheries management includes re-stocking with food fish species.	Government-IFCD collaboration in breeding and hatchery technique provided initial impetus for work on the species.	Diminishing coastal fishery resources has increased the priority of aquaculture of food and especially reef fish species in government development plans	
Research	IFCD expertise enabled spawning, seed production and broodstock development;	*Appropriate feed for broodstock development and for fry; spawning; hatching percentage; fry survival*		*Security and probably poverty: (Already developed broodstock vanished).*
Extension				Siganids are a preferred species in Micronesia
Institutional collaboration & partnerships	MIMRA-CMI Land Grant and MIMRA-IFCD (Taiwan) collaboration in hatchery R&D			
Keys to success	Expertise brought in through bilateral assistance enabled establishment and operation of the broodstock development			
Major constraints	*Feed and livefood for fry for both species; lack of adult males for the groupers.*			

4. Seaweed

Enablers/constraints	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Government initiated the trial to introduce (red) seaweed.			
Research	Damage from predators especially the turtles could not be controlled, which put a stop to the trials.	Hatchery constructed for seedling production.		
Extension				
Institutional collaboration & partnerships	Assistance from FAO			
Keys to success				
Key constraints	*Predation; market would be viable if it passed the technical feasibility test*			

Country 3

Kiribati
22 – 27 July 2010

I. Introduction

The three species that can serve as illustrative examples of the development of certain species for aquaculture in Kiribati are milkfish, red seaweed and giant clam. Trial on pearl oyster to establish its feasibility for investors yielded poor quality pearls; a comprehensive desk study of the possibility of introducing a marine shrimp species (i.e. *Litopenaeus vannamei*) for culture by Fitzgerald (2002) concluded that it would not be economically viable either for the domestic market or for export; and sea cucumber is being produced in the government hatchery for re-seeding of over-exploited grounds but as yet with no assessment of its results. Other species which have been tried in the past are brine shrimp, cockles, mojarra, molly, mullet, and mussel. In the late 1990s trochus was transplanted from Fiji to a quarantine facility in Tarawa and subsequently to an outer island.

II. Background information

The Fisheries Division of the Ministry of Fisheries and Resources Development (MFRD) is responsible for aquaculture development. Kiribati has a few enabling provisions that pertain to aquaculture in the Fisheries Act. There is no specific legislation governing aquaculture. Under the Fisheries Ordinance the "Minister may take such measures as he shall see fit to promote the development of fishing and fisheries to ensure that the fisheries resources of Kiribati are exploited to the full for the benefit of Kiribati." Under Part V: (Miscellaneous), the Minister or the President may make regulations that provide for the licensing of fish farms and the regulation and importation of live fish and regulating the taking of coral and seaweed. Responsibility for policy and management matters relating to aquaculture is vested in the Fisheries Division under the Ministry of Marine Resources Development.

The Ministry of the Environment and Social Development, through its Department of Environment and Conservation, has some responsibilities in evaluating the impacts of marine development and activities. A provision in the Environment Act of 1999 states that, "… seaweed farming, land or marine foods processing or farming … fishing ponds industries, introduction to Kiribati of non-native (alien) species" are referred to as 'prescribed developments'. The Act mandates stringent control measures and requirements for prescribed developments. The approval process for prescribed developments requires an applicant to submit either an initial environment evaluation report, together with any additional requirements as notified by the Secretary or a development application accompanied by an environmental impact statement and any additional requirements requested by the Secretary. Foreign investors are required to submit a certified copy of the Foreign Investment Commission's certificate together with an application. The Environment Act also controls the discharge of pollution from prescribed premises through the requirement to obtain a licence.

The history of aquaculture development in Kiribati goes back to 1975 through establishment, with FAO technical assistance, of a 4-hectare milkfish pilot production farm in Ambo on the island of Tarawa for bait. The original purpose of bait production, which was technically and economically viable, was rendered irrelevant when the tuna pole and long liners decamped from Kiribati and moved to Fiji. It was then decided to grow milkfish for food as there was a local preference for the species and there were then prospects for export to Marshall Islands and Nauru. A larger farm of 40 ha was constructed in 1977 out of a separated portion of the Tarawa lagoon. This piece of tidal flat in Temwaiku was cut off when the causeway to the new airport was built and converting it into a milkfish pond system achieved the twin target of turning a potential eyesore (it was becoming a fetid swamp) into a productive aquaculture complex (Onorio and Teroroko 2010 pers comm). This was expanded to 80 ha in 1980. The Ambo ponds were reconstructed in 2000. The resulting farm consists of 5 ponds with a total pond area of 1.1 ha. Both sites are under the administration of the Fisheries Division of the Ministry of Fisheries and Marine Resources Development (MFMRD); the Ambo farm is currently being operated by the Taiwanese Technical Mission under the International Fisheries Cooperation Development for broodstock development with the view of producing hatchery-reared milkfish seed.

The 80-ha farm is now called EcoFarm and has added a poultry (layers) and pig (for piglet production) enterprise. This adds to its products and is a source of manure to fertilize the ponds to improve primary productivity (by the production of a zoo- and phyto-plankton mat called lab-lab that is food to milkfish grown under an extensive culture system of 2-5 fish per m^2 with or without supplemental feeding).

Red seaweed (*Kappahycus* sp), first trialled in Tarawa, is now solely produced in the distant atoll of Fanning. A government company was established for seaweed trading and some 1000 tons of dried seaweed is produced annually and sold to a Danish colloid company whose factory is based in Cebu, Philippines. The target is 1500 tons but it has not been attained (Teroroko, 2010, pers comm).

*S*eaweeds have been cultured in Kiribati since the early 1980s and farms established in suitable atolls throughout the country's three island groups. Exports commenced in 1990 when the government-operated Atoll Seaweed Company established to foster this industry and 100mt was shipped for processing by a Danish colloid plant. Production increased significantly in 1995 following the establishment of a new programme of technical support by the Government. Production in 2000 was 1,435mt of which 1,381mt came from the Line Group. Production volume has consistently stood at around 1,000mt/annum, worth around USD0.5million F.O.B. Recent development of tourism in three islands has seen a shift from seaweed production to tourist related livelihood activities (e.g. souvenir making) and this has led to a significant decrease in seaweed production from the Line Islands.

The third species is giant clam. The government hatchery produces seed for re-seeding. A private company engages in commercial farming and trading. It produces spats reared to the suitable size in its hatchery and nursery complex, and distributes these to selected farmers in two nearby atoll communities for on-growing to aquarium size, buys them back and exports them to an aquarium company in Germany. The farm provides the nets and technical advice and buys in cash twice a year, before independence day and before Christmas (Foki 2010 pers comm).

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indicators for the mission to follow up.
2. Reports relevant to fisheries and aquaculture.
3. Face to face interviews with key informants; these included retired and active policy, management, and technical personnel in the Fisheries Division of the Ministry of Fisheries and Marine Resources Development.
4. Visits to a government milkfish farm (EcoFarm) with poultry and livestock enterprises; a Taiwan Technical Mission project farm developing milkfish broodstock and a private-owned giant clam hatchery and nursery.

IV. Findings

This mission report provides indicative and broad findings, which are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. A number of gaps in the legal framework for aquaculture were identified (Tsamenyi 2005) for consideration, as follows (i) The need to harmonise laws and policies dealing with aquaculture leases and traditional marine tenure regime for sea space to avoid conflict; the need to have policies that will ensure the exclusivity of the sites. These policies need to be in fairness to the local community. The issue of aquaculture leases for land has not been provided for under the Fisheries Ordinance. Furthermore, licensing and permit procedures have not been formally provided; as seaweed aquaculture is becoming a major industry, while other forms of aquaculture are in their infancy, a framework for its regulation is needed to ensure investment security in the later stages of development, with particular emphasis being paid to the sensitive issues of land acquisition and rights accrued, to avoid stakeholder conflicts, especially between native landowners and private entrepreneurs; other policies in relation to environment protection, disease control, and quarantine matters specific to aquaculture requirements also need consideration. For example, the unregulated introduction of the exotic species tilapia and mosquito fish (*Gambusia* spp.) constrain the aquaculture of milkfish.

2. Management and protection of endangered species, currently comes under the Fisheries Act's Section 22, and the Environment Act's Section 24. The Ministry of Fisheries and Marine Resources Development is also working closely with Island Councils on establishing marine managed areas to address the issue of declining marine resources such as giant clam, sea cucumber, and shellfish species.

2. Aquaculture initiatives and impacts

The species (and systems) species that have been initiated in Kiribati and a brief description of their results are described in the table below.

1. *Milkfish*. Milkfish is the major cultured fish species with two major farms operating in Christmas Island and South Tarawa and an experimental cum production farm in Ambo. The 80-ha farm now called EcoFarm has never operated with great success, partly because of infestation of the ponds by introduced tilapia, and partly due to the performance difficulties of the national pole-and-line fleet. There are plans to again produce frozen bait for foreign longliners. But an almost intractable problem is the heavy infestation of the ponds by *O. mossambicus* introduced in the 1950s by the Department of Agriculture. The pond system is constructed for gravity feeding of the lagoon water i.e. below the low tide level and therefore would be difficult and expensive to drain. Attempts have been made to try to eradicate the tilapia by drying up some ponds but the infestation resumed. Apart from the lagoon, shallow water bodies beyond the farm's perimeter fence are infested by tilapia. The best the farm could do was separate the tilapia from the milkfish harvest and turn it into fish meal added to the poultry feed.

   The EcoFarm has included a poultry and livestock enterprise with some success; the produce - eggs and piglets - add to the revenue which is enough to cover operational expenses and wages of the farm manager and the workers (the pond manager who had retired, was re-hired and paid by the government; he is a veteran milkfish technician with extensive hands-on training in the Philippines). There is much scope for improving the skills of the work force.

   Primary productivity of the ponds is poor and enhanced with fertilization by the manure from the poultry and pig farm and with some homemade farm feed supplement. Yields are extremely low compared to similar extensive scale operations in other countries and the harvests are small. This is owed largely to the infestation of the *mossambique* tilapia and entry of some predators. Any harvested fish however is quickly sold. The farm produces smoked milkfish in a small kiln that sell for 4 AUD per 500 gram vacuum packed milkfish. It is also much preferred particularly for parties and other social celebrations. Poaching is a problem.

   The Government has also been promoting small scale milkfish farming in suitable outer island areas but supply of fry has been a constraint despite the abundant natural population in the Kiribati waters, including the Kirikimati (Christmas) Islands lagoons.

2. *Red seaweed* (*Echeuma alvarezii*). It showed much promise and became a major export that spurred the government to establish a government company to engage in its trading. It was introduced in 1977 from Hawaii and full commercialization was attained in 1986 following numerous trials on farming methods and marketing. Only *E. alvarezii* was grown afterwards because of the very slow growth of *E. spinosum*. With the establishment of ten potential sites in the main Gilberts groups, six of them have proven commercial farming viability. Setbacks included marketing and farming due to insufficient knowledge and limited experience in this new industry. Eventually seaweed farming gained acceptance, and overseas markets have been secured (Uan, The initial enthusiasm among farmers in communities waned - other than the growers in Fanning Atoll (where almost all of the production from culture now comes from). Part of the reason is because of the low income or slow payment for the harvest. Another is the rise of other more rewarding activities such as souvenir making and servicing of tourists. Also, when the copra price goes up, the farmers would invariably neglect the seaweed farm. A culturally related reason, sometimes cited for the sustained production from Fanning Atoll, is that the farmers there are settlers from different places who have long struggled to eke out a livelihood.

3. *Giant clam*. Hatchery reared and stocked into deep water. Reseeding continues but results as yet are not well assessed; a private company appears to have a viable business model with aquarium size clams (mainly *T. maxima*) but few farmers are benefited. Its impacts include reduced pressure on wild stock through the export of hatchery-reared clams, income generation by the farmers chosen to grow the clams, and a new source of export commodity although wild harvested clams have been known to be extensively exported, which has led to the depletion of the wild population.

   Giant clams have been extensively harvested, resulting in the declining of stocks, particularly *T. gigas*, across the three main island groups, especially the Gilbert Group. Two companies are involved in the marketing of giant clams for local consumption, and one - Atoll Beauties, a private company - for export of cultured clams. The clams are hatchery-reared and then distributed to village farmers who grow them to aquarium size and then sell them back to the company. The current annual production of the company is around 2,000 giant clams, but is expected to increase to between 5,000-10,000 ind/yr. There is also a growing interest in giant clam farming in the Line Group of islands. This group of islands is where most of the fish collection occurs for companies supplying the global marine aquarium trade. The government is supportive of this as it sees giant clam farming as one of the potential areas for sustainable economic development. High transportation costs and difficulties in entering markets are some of the major constraints that need to be overcome.
   There is not much extension effort in establishing co-management regimes for the seeded stocks and the remaining wild stocks.

4. *Pearl oyster* (*P. margaritifera*). The trial was intended to explore its economic feasibility for local and foreign investors. While production was satisfactory, pearl quality was poor. An alternative that was proposed is to produce mabe or half pearl using *Pteria* penguin species but so far no private investor has come forward. Poor quality and a high capitalization combine to discourage investors. No economic feasibility study has been carried out on the production of mabe or half pearl to serve as a business guide to prospective investors.

5. *Sea cucumber*. It was being produced at a pilot level. The high demand for trade has led to the over-exploitation of the natural population. The government hatchery could not supply enough and there are technical questions about site selection, and the procedure for enhancement and management of seeded stocks. The objectives of the sea cucumber enhancement programme - particularly of the white teat species (*Holothuria fuscogilva*) are to maintain a steady supply of sea cucumber from the wild and serve as a source of income for farmers. Their achievement has been constrained by difficulty of sourcing broodstock, high cost of hatchery maintenance and operation, and apparently lack of viability of seeded stocks (i.e. monitoring showed very few released animals).

   As with giant clam, there is no co-management regime developed or implemented with the concerned communities.

6. *Trochus*. Introduced from Fiji, hatchery produced seed have been stocked in seabeds but results are not monitored. There is as yet no visible impact as there has been no monitoring of the results in the Outer Islands. The seeding in South Tarawa resulted in a high mortality. No diagnosis on the cause of the high mortality has been made.

3. Lessons

The lessons from the previous and current aquaculture initiatives are based on the analysis of the important farming system/species using an analytical framework that focuses on the feasibility issues of farming or producing the species, namely biological, technical, economic and social. This analytical framework has been applied to the screening of a potential species/ farming system before it is recommended for further pilot test in a wider domain or for adoption by farmers. It is applied here to systematically determine the issues attendant to the culture of a species. (The logic of this scheme appears as Annex 3 of the Synthesis). The analysis for the important and potential species appears as Annex 2 with milkfish (*Chanos chanos*) as the illustrative example. The other species are giant clam and red seaweed.

3.1 General lessons

The general lesson from the aquaculture development efforts of Kiribati is as follows:

3.0.1. The milkfish development initiative had the benefit of expert assistance from an FAO technical assistance programme and the seaweed development project from professional expertise of other technical assistance agencies. The longer-lasting legacy of these and subsequent assistance programmes were the strengthening of manpower for aquaculture which included the training of young Kiribati technical personnel in graduate and high-level skills development programmes in other countries such as Australia, Fiji, Japan and the Philippines.

3.0.2. The training of personnel strengthened the capacity of the country for planning, project development and management as well as production and trade in aquaculture commodities. The trained personnel then spearheaded the institutional capacity building of the entire fisheries agency. The impact is that aquaculture development began to gain a higher profile in the social and economic development plans of Kiribati.

3. 2 Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the species in Annex 2.

1.1.1. Strategic:

- Milkfish. Overall the milkfish development project showed that low input- low tech aquaculture operation is suitable; demonstrated the feasibility of a low-tech operation for subsistence farming; demonstrated the economic feasibility of product processing for a local market and the economic feasibility of an integrated farming system with aquaculture as the main enterprise. The 80-ha EcoFarm has created employment opportunities. Improving its performance would require more highly skilled workers and more workers employed.
- The switch to foodfish production from the original purpose of bait production was an important strategic, albeit unplanned, move; it was driven by the decamping of the clients for baitfish i.e. the pole and long liners to another country. The volume of production from the 80-hectare farm, were it as productive as equivalent extensive farms in other countries, however, would have resulted in a huge glut in the local market. One expert's optimistic projection was more than 4 tons per hectare. Even half of this would have seen a volume of 160 tons a year of harvest (for a supply to the Tarawa population of almost 5 kg of milkfish per capita). In the event, the yearly production of the entire farm had been less than half a ton. Ironically, the low productivity leaves room for the setting up of smaller scale commercially oriented or subsistence farms on the island of Tarawa.
- Milkfish seed production. The Taiwan Technical Mission (TTM) aquaculture project objective is to produce hatchery-reared fry to have a reliable supply of seed for the 80-ha large farm and the other farms in the outer islands. This strategy would avoid having to recruit natural wild fry into the ponds with the high possibility of bringing in predators and the ubiquitous *mossambique* tilapia. It is a sound objective except for the length of time the farm has to rear the selected fish from broodstock to maturity. The alternative might be to train rural people to collect and sort out milkfish fry as a supplementary source of income, since there is an abundance of wild fry in the waters of Kiribati. Transport techniques for fry would also be necessary.

- Seaweed. The decline in interest of farmers in seaweed growing had been the result of mixed factors: low income from the harvest, delayed payment, and the competition for farmers' attention from other sources of income such as souvenir making and copra (particularly when the price of copra goes up). This was a more fundamental and on-farm problem than marketing and logistical constraints.
- Giant clam. Kiribati is not a member of OIE and CITES; this has posed some constraint to the trade in giant clam. Membership entails costs. However, the assistance of SPC has enabled non OIE members to export to EU as long as the countries provide reports of their animal health status.

1.1.2. Management:

- Milkfish. The EcoFarm in Temwaiku and the TTM experimental and seed production farm in Ambo could benefit from a closer interaction and collaboration with each other.
- Giant clam. As with other countries, the re-population objective of the giant clam project has seen very limited results and is therefore of little social and economic benefit to communities especially in the outer islands. The trade in aquarium size clams however has attracted one entrepreneur whose business strategy has the advantage of being able to benefit small farm households (albeit only a few), generating employment in his hatchery and among the out-growers, and providing a model for an export-oriented enterprise to the country. It is also noteworthy that government is not in the business of exporting and thus not competing with private enterprise.
- Giant clam. The private farm is now listed as a tourist destination, which points out the additional economic contribution to the farming of the species, or better yet, having a protected area accessible to tourists that has natural or seeded populations of large giant clams.
- Seaweed. The government's establishment of the Atoll Seaweed Company to oversee the seaweed industry gave a strong impetus to its development. The focus on the logistical problem of handling, transporting, quality control, and developing contractual arrangements with a buyer was an understandable and correct strategy given the distances of the sources of supply and the distance between Tarawa and the colloid processing centres. These are the downstream activities of the industry and thus crucially require expertise in business management.

1.1.3. Technical

- Milkfish. The integration of poultry and livestock components into the farming system has improved the overall productivity and revenue of the farm. Product processing for added value i.e. smoking has improved the local market.
- Milkfish in outer islands. A pilot project set up in the Gilbert Island - the Nikunau Pond - depends on fry from Tarawa, which has clearly posed several difficult technical problems that include transportation costs, handling, reliability of supply, and viability of the seed.
- Milkfish. The heavy infestation of tilapia of the 80-ha EcoFarm and even the previously tilapia-free Ambo experimental farm, exacerbated by the entry of predator species such as barracuda, is now almost an intractable problem that needs a drastic strategic decision from government and a search for technical solutions. The decision might entail stopping production and overhauling the pond system. Pond system reconstruction can be costly as has been done with the Ambo farm, which is still plagued by tilapia infestation. Clearly, then other measures need to be tried.
- Milkfish value addition. The smoked milkfish commands a good price and an upscale market in Tarawa. It has scope for further improvement in the process, quality and packaging. There might also be a possibility to export the product.
- Milkfish. The TTM has developed a feed formulation for the broodstock the ingredients of which are available locally. While it is needed in relatively small quantity for now, this could become the foundation for a local small to medium scale aquaculture feed industry. (The tilapia might yet become useful as a raw material).
- The Giant clam. The capacity of the private farm is currently limited and there might be scope for using, some of the spare government hatchery facility if available. It is now partnering with the TTM project by having some of its spats grown to ready-for-growout size at the Ambo farm clam raceways.

V. Conclusions

Kiribati has invested national and donor resources to develop the mix of aquaculture species that has grown from one i.e. milkfish, to more than half a dozen over a 25-year period. This is not out of line, as the same trend has been seen in Asia. Other than milkfish, it is widely agreed that red seaweed became a very promising species for income generation in atoll communities and for export; the establishment of a government company devoted to the seaweed industry attests to the potential that the species had shown. The subsequent stagnation in the production of cultured seaweed - mainly due to a much reduced enthusiasm and participation of seaweed farmers in the outer island (except those in Fanning) who were the target beneficiaries of the programme - has raised questions on the continuing viability of exporting seaweed as a raw material (which is a high-volume low-value product) with only drying and packing as the additional inputs, but with no value addition. This question applies to all the seaweed-growing PICs all of which have the resources and natural endowments to be able to produce a large volume of quality seaweed. The questions of how to achieve competitiveness and attain economy of scale could be resolved by a Pacific-based colloid processing plant. A technology for intermediate processing in-country to capture some of the value from the material as well as to have a much less volume for shipment can be an alternative. An inquiry from the consultant with a seaweed farming and processing industry expert and business person in Cebu, Philippines however indicated there is no such technical option at present, other than a chipping technique that converts dried seaweed into chips for easier and lower-volume shipping. The chipping machine can be operated by women.

As with other Pacific island countries and territories, the work on reseeding to repopulate or enhance depleted natural populations of various species such as giant clam, sea cucumber and trochus is a continuing activity taking up a significant amount of attention and national and donor resources. There has been very limited success with the objective of repopulating overexploited fisheries, particularly of sea cucumber and giant clam. There might be need to take stock of the progress of these efforts from a regional standpoint and to agree on a region-wide and long-term strategy on enhancement of the important regional species. Trochus reseeding which has shown success in a number of countries - but not in Kiribati - can provide some valuable lessons.

The rather wide range of species being developed or explored for farming is not a bad thing; different species can provide employment, food and income to different segments of the population, or they can complement existing livelihood sources, or be incorporated into a mix of farming systems. The risk however is a diffusion or lack of focus and the inevitable need for the R&D capacity to support the development and promotion of the species/farming system. As it is, the resources for R&D in countries like Kiribati can be quickly overwhelmed by a multiplicity of research, development and extension issues to address.

A rather politically flavoured issue related to "focus" was also raised, not only in Kiribati but in Marshall Islands; the many and varying demands from the different atoll communities on a centralized R&D organization for fisheries and aquaculture is not a technical issue but does have technical implications. A prioritization of aquaculture needs matched by the strengthening of the appropriate technical support could provide some answers.

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Annex 1

Persons Met in the Republic of Kiribati

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2. Tukabu Teroroko, Director Phoenix Islands Protected Area. Formerly Director of Fisheries, Deputy Secretary and Permanent Secretary of Ministry of Fisheries and Marine Resources Development (until 2006) tukabut@gmail.com

3. Iaira Mauarere, Pond Supervisor, EcoFarm, Temwaiku

4. Jeaeki Iuta, Farm Manager, EcoFarm

5. Bareiri Onorio, Businessman, former Permanent Secretary of Fisheries and Marine Resources Development,

6. Tsan-Ping (Kevin) Wang, Assistant Specialist, Researcher, Taiwan Technical Mission in the Rep of Kiribati (ICDF), Milkfish Broodstock and other Finfish Development Project, Ambo

7. Ribanateake Awira, Permanent Secretary, Ministry of Fisheries and Marine Resources Development

8. Kintoba Tearo, Director, Fisheries Division, MFMR

9. Romain Foki, Technician, Giant Clam Farm, Abatao North Tarawa

10. Toaea Beabeiatemea, Senior Fisheries Assistant, Fisheries Division, MFMRD (technical guide to mission)

Annex 2

Feasibility issues of selected species/farming systems, Republic of Kiribati

1. Milkfish

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Government's priority species included milkfish; decided to establish a milkfish farm in a degraded piece of the Tarawa lagoon.	There was need for expertise to carry on with the initial work from experts of donor and development assistance agencies; the government sent national staff for higher level technical training abroad.		The government promoted or provided assistance to subsistence farming in Outer Islands; it also has set up a pilot farm in an outer island.
Research	*Tilapia infestation and predator species is extremely severe*	*Fry from Tarawa for Outer Island pilot farm is costly to transport and likely with viability problem*	There is a preference for milkfish by the population.	
Extension				
Institutional collaboration & partnerships		FAO, TTM of Taiwan, and OFCD of Japan had provided assistance to MFMRD in various aspects of milkfish farming		
Keys to success	Good consumer acceptance of milkfish both fresh and smoked.			
Key Constraint	*Severe infestation of tilapia O. mossambicus in the milkfish production farm (EcoFarm) and experimental farm of the Taiwan Technical Mission in Ambon*			

2. Giant clam

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy		Government has placed a high priority on clam propagation and re-seeding	Farmers are paid immediately for the clams that the private farm buys back from them.	
Research	Suitable species were introduced. *But the reseeding programme is also faced by the reproductive requirements and behavior of giant clams*	Standardized and well known hatchery and growing protocols in the Pacific.	*High transport and handling cost*	
Extension		*Need good compliance with CITES and OIE requirements but is a non member to either organization.*		*Over-harvesting and probably some poaching*
Institutional collaboration		Assistance from SPC on exportation of clam to comply with trade requirements.		
Keys to success	For the aquarium trade: a workable business model developed by the entrepreneur. Well known and already standardized hatchery and culture technology in the Pacific region.			
Key Constraint	*or the reseeding programme, the difficulty of protecting the seeded areas.*			

3. Seaweed (*Kappaphycus alvarezii*)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Promotion by government of widespread seaweed culture in suitable seaweed grounds.	Government has established a company in charge of the seaweed industry, particularly its trading.	Private sector participation is not being considered and likely not encouraged because of government's virtual monopoly of the trade.	The settlers in Fanning which is the sole production site of seaweed have the skills and motivation to farm seaweed.
Research			*Value addition and some local processing for the local market is not a research priority; no capacity for research on processing*	
Extension				
Institutional collaboration & partnerships				
Keys to success	Good seaweed production grounds;			
Key Constraint	*Economy of scale and lack of competitiveness are difficult to achieve when supply sources are widely dispersed and distant.*			

4. Pearl oyster (*Pinctada margaritifera*)

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy		Demonstration of technical feasibility for prospective investors	Government effort to encourage private sector investment	
Research	*Low population density of wild pearls*	Hatchery production was successful. *Low quality of pearls produced*		
Extension				
partnerships Institutional collaboration &				
Keys to success	Finding an economically viable utilization of mabe or half pearl.			
Key Constraint				

5. Sea cucumber restocking

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	The government identified a choice species for propagation and for use in enhancement of depleted fishery areas.	A sea cucumber hatchery was established for re-stocking purposes (and also used for pearl oyster).	*The popularity and the lucrative trade in sea cucumber made the natural population susceptible to over harvesting, which is what happened.*	
Research	The wild populations in the Outer Islands – that are unexploited are the sources of broodstock.	Stock enhancement procedures and management of seeded stock is seen as needing further technical improvement	*There has been no technology to capture more value from the raw material.*	
Extension				Appropriate co-management arrangements with atoll communities are a crucial need to maintain the seeded stock and manage existing resources. *Lack of it is the likely cause of unsuccessful seeding efforts.*
Institutional collaboration & partnerships				
Keys to success	A co-management agreement with the communities that enables them to have a sense of ownership of the seeded stock; a continuing seed production operation.			
Key Constraint	*Over harvesting; lack of capacity for proper stock enhancement and management*			

Country 4

Vanuatu
30 June-04 July

I. **Introduction** ent is seen as a potential sub-sector for increasing fisheries production. The history of aquaculture in Vanuatu has been marked by a mix of aborted efforts and successful initiatives that were carried on to a commercial scale. The strategic objective of the fisheries sector is to improve the industry's efficiency so it can supply a larger proportion of the protein needs of a rapidly growing population from local fish stocks, and to sustain limited fisheries resources. From its beginnings in 1972 through the 1980s and on to the 1990s, aquaculture development has mostly involved feasibility trials and an unregulated active interest in specific niches such as growing oysters for the tourism industry. However, in more recent years investors have taken an interest in the sub-sector and commercial aquaculture farms have been established, notably for marine shrimp and finfish particularly the improved strains of tilapia. Stock enhancement of the popular trochus and giant clam species are generally successful albeit the efforts have been, as in other Pacific countries, a reactive measure to make up for the extensive and rapid exploitation of the natural stocks of these species. In the end the original purpose of re-stocking giant clams for food has seen very limited success although its culture for the ornamental trade has been in some ways a commercial success.

Various technical assistance projects have been extended to develop the aquaculture sector of Vanuatu, mostly targeted at developing specific commodities. These have included an FAO SAP technical assistance, with USP expertise, to explore the feasibility of culturing GIFT tilapia and giant freshwater prawn by small scale farmers; ACIAR assistance on seed production and community based stock enhancement of trochus; JICA assistance in the hatchery breeding and reseeding of green snail and of giant clam; and the monoculture as well as integrated farming of the endemic species of freshwater prawn (*M.lar*) with SPC expert assistance. The government, with private sector collaboration, explored the small scale as well as commercial scale potential of seaweed, pearl oyster, marine shrimp, and the improved strains of tilapia (GIFT and red).

An Aquaculture Development Plan for 2008-2013 (SPC 2008) has been formulated through a multi-stakeholder consultation led by the VFD and assisted by the Secretariat of the Pacific Community (SPC). Part of the strategic action is to formulate aquaculture policies and regulations because there is no specific provision for aquaculture development in the Fisheries Act. The Plan also targets the building of personnel and institutional capacity to support and regulate aquaculture development. Continuing efforts will be made to standardize the technology packages for the priority commodities and farming systems for the small scale farmers and for commercial enterprises. A remarkable development is the renewed and increasing interest from entrepreneurs who are investing into the establishment of commercial farms.

II. **Background information**
The references for the background information include the report of a pre-feasiblity study on the potential of farming tilapia (*O. niloticus*) and freshwater prawn (*M. Rosenbergii*) in Vanuatu conducted through an FAO SAP technical assistance by Satya Nandlal, then with the University of the South Pacific; the Vanuatu Aquaculture Development Plan 2008-2013 prepared with technical assistance by the Secretariat of the Pacific Community; a powerpoint presentation on the subject "Medium-scale tilapia production in Vanuatu" by Paul Christian Ryan, Manager of the Pacific Ocean Gardens, an aquaculture enterprise culturing finfish; and the 2001 Fishery Profile of Vanuatu.

The history of aquaculture development in Vanuatu is concisely described in the Vanuatu Aquaculture Development Plan 2008-2013 (SPC 2008). It began in 1972 with the introduction of mangrove oyster; it was discontinued when spats from the US came in with pests that destroyed the existing stock. One un-enviable highlight, shared by other South Pacific Countries and Territories, is the introduction in 1980 of *Oreochromis mossambicus* into lakes and other water bodies as a mosquito control. It has since become a noxious species (in Kiribati especially as well as in Vanuatu) although in some cases

as in Solomon Islands and Cook Islands, a wild fishery of the species has established and has become accepted as a food fish. The effort that began in 1985 to restock trochus population by hatchery-bred seed distributed to communities for stock enhancement is seen as a success. One of the most extensive aquaculture activities in Vanuatu is the induced spawning, rearing and reseeding of trochus. Trochus shell was an important export commodity, along with green-snail shells and sea cucumber, prior to 1990. The high demand led to its overexploitation. The Vanuatu Fisheries Department (VFD), with the assistance of development partners, started operating a trochus hatchery and reseeding programme in early 1990. Juvenile trochus are planted on community reefs to help replenish stock and sustain a long-term reef fishery regulated through community management systems. An exploratory work on pearl oyster culture concluded that the native stocks of blacklip oyster are not dense enough to support commercial production, so that no further work was made. In a similar vein, trials in red seaweed (*Kappaphycus alvarezii*) farming were discontinued for economic reasons despite communities lost interest due to insufficient revenue from their harvest. Into the 2000s, renewed efforts were made on the reseeding of giant clam for the ornamental trade and green snail for food and ornamental materials. In recent years, the commercialization objective of the government has yielded encouraging results with a few investors establishing shrimp and finfish farms. Among these are the Teouma marine shrimp farm that harvested its first crop in 2005 and the Pacific Ocean Gardens that utilized a degraded freshwater body for cage culture of red tilapia in 2006 and now - with gradual acceptance of tilapia by the local population - has an increasing market. Freshwater prawns are also making the transition to full small-scale operation among rural communities. Aquaculture of ornamental commodities, such as giant clams and coral, has also attracted the interest of local and private investors.

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indications for the mission to follow up; it was not however returned by the VFD.
2. Reports relevant to fisheries and aquaculture.
3. Face to face interviews with key informants; these included policy, management, and technical personnel in the Vanuatu Fisheries Department and a telecommunication exchange with a private entrepreneur. The list of persons met or called on the telephone and exchanged emails (in the case of the private tilapia farmer) forms Annex 1.
4. Visit to government hatchery facility for trochus, green snail and giant clam.
5. Meetings with SPC aquaculture specialists (in Port Vila and in the SPC Headquarters in New Caledonia)

IV. Findings

This mission report provides indicative and broad findings. The findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. As with other Pacific countries a significant state investment into the R and D and marketing of giant clam, trochus, corals and green snails
2. Commercialization is a primary objective with the government investing heavily in the feasibility trials and standardization of technology packages.
3. The biosecurity measure of government relies on quarantine and mitigation of ecological risks from introductions. One measure is to preclude the private sector from conducting broodstock development and seed production of introduced commercial species such as tilapia.
4. The overall objective of the aquaculture development plan is to improve the opportunities for private sector investment, in line with the government's programme of commercialization. It lists seven critical areas to be addressed These are:

- Formulating an aquaculture policy and legislation
- Establishing credit for aquaculture farmers
- Providing infrastructure and basic utilities including transport
- R and D to address bottlenecks in production and marketing
- Environmental management and biosecurity
- Extension support to farmers and communities
- Human resource development

5. The success of the tilapia and marine shrimp farms underline the importance of the government's role in improving the investment opportunities for aquaculture. This includes biosecurity protocols that are adequate but not onerous and assistance in reducing production, marketing and financial risks.
6. The important role of private investment is highlighted by the coral and giant clam trade and the shrimp and tilapia farms.
7. Small farmers adopting freshwater prawn integration into their taro farms demonstrates the need to develop suitable and economically rewarding farming systems for small farm households.

2. Aquaculture initiatives and impacts

The species (and systems) species that have been initiated in Vanuatu, and a brief description of their results are described in the table below.

1.	*Giant clam* - probably the most successful and sustained aquaculture system, with continuing government support; aquarium trade has provided the commercial impetus. The fundamental objective of re-seeding to restore depleted population has seen very limited success. The economic impact has therefore been limited to a few households that are chosen to grow the clams to aquarium size, with the largest share of the value being taken by exporters and traders.
2.	*Trochus*. Paradoxically, because of a lucrative international market, it was the over-exploitation of the natural population that gave the impetus to the intensive government effort at propagating the species and re-seeding the reefs.
3.	*Tilapia cage culture* (GIFT and red strains). The current success, of the private commercial tilapia farm shows that (i) tilapia is an important substitute or complement to wild fish (the farm schedules its harvest during seasons when coastal fishing is limited or not possible due to inclement weather), a precursor to the role of farmed fish when inshore fishery resources might eventually be depleted; (ii) an environmentally degraded and noxious-fish infested water body can be turned productive with such system as cage culture of a species like tilapia whose culture technology is well developed and disseminated; and (iii) a local demand can make its farming profitable.
4.	*Red seaweed* (*Kappaphycus* sp). Trials proved the biological feasibility of growing seaweed but it is the technical and economic issues that have prevented its commercial development. Farmers were not assured of income from their harvests but this is because the market is distant and a seaweed industry would lack competitiveness. The almost intractable issue is competitiveness (against the industries in Asia, particularly Indonesia and the Philippines) until such time as there can be some value addition at the farm or national level, or a strategically located Pacific-based colloid processing plant.
5.	*Macrobrachium* spp. The presence of an endemic species *M. lar* allows small farmers to use wild fry for integration in a cropping system; however it is limited to subsistence farming. A monoculture system would enable higher production and provide higher farm incomes but the farmers would have to rely on hatchery grown seed. *M. lar* so far has not been successfully domesticated i.e. its life cycle has not been completed in captivity.
6.	Corals are not extensively cultured. Only 2 percent of the traded corals are cultured, the bulk is collected. It requires a large capital investment to set up a coral trading scheme that includes the facilities, technology and logistics for pre-shipping and shipping. The lucrative trade however has provided a future option for aquaculture of corals and live rocks by small farmers. The current arrangement of exporters providing technical advice to collectors to assure quality corals can be subsequently extended to providing extension advice and training for coral growers. This function can be assumed by the private sector.

3. Lessons

The lessons from the previous and current aquaculture initiatives are based on the analysis of the important farming system/species using an analytical framework that focuses on the feasibility issues of farming or producing the species, namely biological, technical, economic and social. (The logic of this scheme appears as Annex 3 of the Synthesis). The analysis for the important and potential species appears as Annex 2 with tilpia (*O. noliticus*) as the illustrative example. The other species are giant clam, freshwater prawn, trochus, marine shrimp and red seaweed.

3.1 General lessons

The general lessons on the keys to success in the development and adoption of a species in Vanuatu for aquaculture include:

3.1.1 The importance of providing a good climate for private sector entry is highlighted by the establishment of the tilapia cage culture farm and a shrimp farm and the success they have shown thus far. The tilapia and marine shrimp farm did not have to conduct expensive exploratory trials because both species are well researched and the technology for culture is available from other countries. They needed government facilitation (for import of materials and use of land and water body) and clear regulations.

3.1.2 The tilapia farm demonstrates the importance of the market in driving innovations in the production system and marketing strategies. These have made the farm environmentally sustainable and the business profitable.

3.1.3 In the context of the Pacific region, as the tilapia farm has shown, a local market can provide a significant incentive for private enterprise to develop a system for local consumption. Commodities targeted for export such as marine shrimp and seaweed were limited by competition; the shrimp against other well established, more efficient producers in the region (New Caledonia and French Polynesia); the seaweed because of transport cost and economy of scale.

3.1.4 The production of relatively higher value species such as giant clam, trochus and corals for the aquarium trade can be carried out with technical efficiency by rural households and small farmers, or by communities, with government advice and material assistance. Their marketing depends on government or private enterprises that have a high capitalization. The government may need to gradually devolve the technical servicing functions to the private sector, in line with its commercialization objective.

3.2 Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the species in Annex 2.

3.2.1 Strategic:

- Giant clam: Income generating and shorter term rewards eventually assumed higher priority over the longer term goals of restoring the reef population and growing them for food; the consequence is fewer beneficiaries. Putting the giant clam, trochus and green snail culture in the context of a coastal management programme, strengthens the culture and resource management objectives.
- Tilapia: The strategic objective of exploring the feasibility of the culture of tilapia for food security and of giant freshwater prawn to improve farm productivity and income was facilitated by regional FAO assistance with USP expertise; the project also facilitated the importation of initial seeds for farm trials. The expert assistance underlines the importance of regional cooperation.
- Macrobrachium: The same strategic lesson as above. In addition, SPC's current follow up studies on the local populations of *M. lar* to provide a guideline for sustainable collection of wild seed for culture by small farms and for larger scale monoculture, underscores the need for a strategic research programme to support aquaculture farming systems development. The programme would include management of the wild resource.

- Seaweed: Unless a means to add value by intermediate processing before shipment to colloid processing plants can be developed, the problems of economy of scale and transport costs will be extremely difficult to surmount. This is a common regional concern.
- Trochus: In accord with the comparative advantage of the Pacific in the production and trade of this species, Vanuatu has shown that sustained technical assistance from government serves to maintain this comparative advantage.

3.2.2 Management:

- Giant clam: community based management of seeded population has mixed results; the heavy input and intensive technical and material assistance from government has diminished the sense of collective ownership and responsibility for managing and protecting the re-seeded population by the communities. This has been exacerbated by focus on production for the aquarium trade which only benefits the few farmers that have buyback arrangements with the exporters.
- Tilapia: Biosecurity measures to address the risk of the new strains escaping are laudable and effective. In light of the introduction of *O. mossambicus* that has turned into a noxious species, and carps and gouramy that have become pests, the government may consider working with the private sector in establishing and operating biosecure broodstock and hatchery facilities with particular emphasis on the single Tilapia farm. This would strengthen the government measures and eventually reduce reliance on import of seedstock, which considerably increases the cost of farming and the risk of disease introduction.
- Macrobrachium: Utilization of an indigenous population i.e. the *M lar* whose seed is collected from the wild can be effective for small scale farming in the absence of hatchery grown seed.
- Seaweed: The Vanuatu experience (and Kiribati) has shown that it is critical to have a system that assures harvests are bought and the farmer immediately paid, because this is a commodity geared solely for income.
- Trochus: The success of the trochus reseeding programme, which has at the same time sustained the fishery and trade in the species, serves as a counterpoint to the mixed results exhibited by the programme on giant clam re-population.

3.2.3 Technical:

- Giant clam: the maintenance of broodstock and production of seed by a well-run government operated hatchery maintains the quality of seed and supports the re-seeding programme.
- Tilapia: Innovations should be market driven within the context of limited local resources. An appropriate marketing strategy to complement the supply from, and avoid direct competition with capture fishery, is required.
- Macrobrachium: SPC's follow up investigation on native populations of *M. lar* and the monoculture of giant prawn highlights the need to broaden the scope of research and development for a species to include the ecological aspects; it follows that the skills of government scientific and managerial personnel should also be enhanced.

V. Conclusions

The formulation of the Aquaculture Development Plan 2008-2013 with the participation of the primary stakeholders and assistance from SPC has accomplished a crucial strategic purpose: it has alerted the private sector to the commitment of government to provide the right conditions for investments. The more active participation of the private sector in planning, R&D and marketing will enhance the overall national effort as resources are limited.

There are a number of achievements from previous initiatives that can inform the execution of the Plan. Future development can also build on these. The success of the tilapia farm provides valuable lessons on government-private sector collaboration. The entrepreneurs assume the risk when they invest into an enterprise. Invariably they also devise strategies to reduce their risks and techniques to improve productivity. Government can effectively provide conditions that minimize private sector risks, without resorting to subsidy. These would include promoting and encouraging the development

and adoption of better management practices that improve technical and economic performance while protecting the environment; only imposing necessary regulations so as not to stifle initiatives and innovativeness by farmers; creating market opportunities without competing with the private sector.

There remains the small scale rural farming sector that the government has a large responsibility to assist. The programme on giant clam clearly shows that the government devotes significant manpower, technical and financial resources as a social obligation. While there are visible benefits of this approach, there might be a need to try alternative strategies. The Aquaculture Development Plan has the underlying theme of commercialization of aquaculture, which is desirable. Implementing it may be easier and more straightforward with well-resourced entrepreneurs and farmers (such as the Pacific Ocean Gardens and the Teouma Shrimp Farm), than with small scale subsistence farmers. The contract farming model or the buy-back model being used by the giant clam exporters could be an option. This needs organizing of the small scale farmers so that technical advice and credit provision is more efficient and they can achieve an economy of scale.

VI. References

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Annex 1

Persons Met in the Republic of Vanuatu

1. Robert Jimmy, Director, Vanuatu Fisheries Department; currently Aquaculture Adviser, SPC.
2. Sompert Gereva, Principal Fishery Biologist sgereva@gmail.com
3. Jeremie Kaltafara, Fisheries Biologist
4. Lincey Dick, Senior Aquaculturist
5. Andrew William, Aquaculturist
6. Timothy Pickering, Freshwater Aquaculture Specialist, SPC (on mission in Vanuatu)

Telephone Conversation and E-mail Exchange with

7. Paul Christian Ryan, Manager South Pacific Ocean Gardens paul@southpacificoceangardens.com

Persons Met in Noumea, New Caledonia

8. Antoine Teitelbaum, Aquaculture Officer, SPC antoineT@spc.int
9. Johann Bell, Coordinator, Climate Change Programme, SPC, formerly Senior Scientist, WorldFIsh johannb@spc.int
10. Being Yeeting, Senior Fishery Scientist, Live Reef Fisheries, SPC
11. Michel Blanc, Nearshore Fisheries Development Adviser, SPC

Annex 2

Feasibility issues of illustrative species/farming system, Republic of Vanuatu

1. Giant clam and Corals,

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Promotion of harvest and export of four suitable species. Introduction of *T.gigas* by the VFD for reseeding.	Focus of governments in the Pacific region on the development of giant clam aquaculture.	The trade in aquarium species continues to be lucrative.	
Research		Technology for breeding, seed production and culture and its management are well-known.		
Extension	Mass seed production in a government hatchery for seeding and distribution to communities.	Simple technology for rearing larvae and seeds.		*Co-management regime is lacking.*
Institutional collaboration & partnerships		Government initiated spawning and culture of one important species *T. crocea* was subsequently taken up by a private aquarium company.		
Keys to success	The government's intensive and continuing effort in the propagation of giant clam for reseeding and for the aquarium trade has been sustaining the aquaculture of the species.			
Key Constraint	*The objective of re-populating the depleted natural resource has been of limited success because of the continuing high demand for aquarium size clams; there is also no effective co-management arrangement with local communities for the seeded stocks*			

2. Trochus (*T. niloticus*) and Green Snail (*Turbo marmoratus*)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy		Focused and sustained government R and D effort on breeding, hatchery, enhancement and community based management. Protection of the seeded populations.	A sustained trade in the shell.	
Research		Improved hatchery facility and procedures for trochus (and green snails)		
Extension			Demonstration of the income-generating potential of trochus culture to rural communities	Community-based management.
Institutional collaboration & partnerships		ACIAR, JICA technical assistance in key R and D areas.		
Keys to success	A sustained R and D work that spanned ten years; sustained demand for the shells; a community management scheme that works; and an effective protection of seeded stocks.			
Key Constrai	*Biological – deteriorating water quality which is related to a legal constraint i.e. the lack of regulations*			

3. Tilapia (*O. niloticus*)

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Freshwater bodies made available; government allows farming of the improved strains of the species. Government allowed farming in an already environmentally degraded and noxious-species-infested water body.	Government introduced *O. niloticus* from Fiji. *Private sector not allowed to breed its own seed.*		Government objective includes farming of the species for food security. *Land disputes (affects security of investment; it has also led to the abandonment of the government pilot farm).*
Research	Strong competition from noxious species (i.e. O. mossambicus) which had been introduced to the Pacific in the 60s.	Technical assistance provided from FAO with expertise from the USP in Fiji.	*Economic and financial guides, in light of the high cost of labor and imported seed, are not available for local entrepreneurs.*	Eventual acceptance by the population of tilapia as food fish.
Extension		Pilot farms established in three areas.		Small-scale farming was demonstrated with some success.
Institutional collaboration & partnerships		Government and private entrepreneur cooperation in addressing biosecurity issues and importation of seed.		
Keys to success	Locally-based entrepreneurship (presence of an investor) and a good domestic market for fresh fish. Technically, the factors that contributed to the success of the private farm are (i) the use of 'appropriate technology' and a proven technology for tilapia culture; (ii) the availability of a local water resource that had already been degraded by deforestation and infested with noxious fish species; and (iii) the availability of local feed ingredients.			
Key Constraint	*Seed has to be imported because of lack of hatchery and breeding work in the country; importation of seed by small scale farmers will not be economical and not very sustainable for small farmers.*			

4. Freshwater prawn (*M. rosenbergii and M. lar*)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	*M. lar* is endemic and government has initiated R and D work for its aquaculture			*Land ownership issues constrain the collection of M lar seed and juveniles in the wild*
Research	Feasibility study and pilot production of the native *M. lar* was initiated by the government	Government provided assistance on farming of *M lar* and M rosenbergii by FAO with USP expertise; continuing assistance on farming in monoculture from SPC		
Extension		Integration with taro successfully demonstrated and taken up by small farmers	A good demand from local restaurants and tourists	
Institutional collaboration & partnerships		VFD benefited from technical assistance from FAO, USP and SPC. A private farm has expressed willingness to produce *M. rosenbergii* seed for community based farming.		
Keys to success	Presence of local species suitable for culture in integrated system or monoculture and availability of the technology for its farming; a good local market.			
Key Constraint	*Culture technology not standardized for local farmers; no hatchery and breeding facility for M rosenbergii*			

5. Marine shrimp (*P. stylirostris*)

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Government allowed the introduction of *P. stylirostris* for farming	Government established facility to quarantine and screen imported seed for disease.	Exemption from taxes on the import of seed and equipment	
Research	Local research on shrimp is lacking	Available technology from other Pacific countries i.e. New Caledonia and French Polynesia		
Extension	No extension or training programme in the country	Presence of trained technicians	Technology package does not include economic and marketing guidelines	
Institutional collaboration & partnerships		Government assisted private sector with importation of seed of *L. stylirostris*		
Keys to success	Public/ private collaboration; presence of an investor; known technology for breeding and culture; biosecurity			
Key Constraint	*Market - local market is limited and local product cannot compete in the export market with other PICTs such as New Caledonia and French Polynesia*			

6. Seaweed (*Kappaphycus alvarezii*)

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy				
Research		Processing to some form beyond dried material at the national level before the product can be exported.		
Extension				
Institutional collaboration & partnerships				
Keys to success	Value addition at the farm and national levels.			
Key Constraint	*Competitveness issue – transport costs are high, economy of scale is not attained; volume of production may not be attractive to assemblers or final buyers.*			

Country 5

Fiji Islands
17-22 August

I. Introduction

The aquaculture sector of the Fiji Islands is noted for the dominance of freshwater fish farming. Tilapia, and freshwater prawn have been the major species farmed, with Tilapia comprising the largest share of the farms, and output. Carps are also farmed. The marine species of giant clam, trochus and sea cucumber are cultured for stock restoration, enhancement and to some extent the aquarium trade, while seaweed is cultured as a supplementary source of income. Brackish water species are shrimp and milkfish. A major commercial venture is pearl oyster farming, currently with two major players.

A national survey of fish farms was recently conducted (it started during this mission) to determine the number and locations of fish farms, assess the economic status of fish farmers, and assess the developments in the sector. The survey would provide a basis for evaluating the freshwater aquaculture development strategy and plan for the period 2005-2010; and to provide more information to the formulation of the aquaculture decree. This has been drafted and is undergoing a series of stakeholder consultations. Some initial results of the survey (from five provinces in the Central Division) are incorporated in this report.

This proposed law is significant in that it will address two major constraints to the development of a truly commercial aquaculture sector - land ownership and heavy reliance of farmers on government subsidy. More than 80 percent of the land in Fiji is under traditional communal ownership. Private commercial investors are concerned about security of tenure. Heavy reliance on government subsidy and technical assistance has been considered counterproductive because it reduces the incentive for a farmer to progress beyond being a caretaker of the crop. Notwithstanding this generous incentive, the initial returns from the recent survey reveal a large percentage of inactive farms i.e. 104 out of 229 (no explanation has been provided as yet but some farmers expressed complaints of lack of market, high market fees for those who are near public markets, high risk from a crop failure, long wait for seed supply, amongst other problems).

The law would create an Aquaculture Advisory Council, a Licensing Committee and a Scientific Committee, whose collective functions cover the critical management needs of the sector. The law would provide for a hierarchy of regulations, policies and plans, and facilitate investments in commercial aquaculture. It has indications for a policy to wean the small-scale subsistence farmers from heavy government subsidy (in seed, feed and even harvesting operations) through cluster or satellite farming (FAO SAP and SPC, 2010).

A critical development issue is land tenure. The Fiji Freshwater Aquaculture Sector Development Plan 2005-10 has a comprehensive identification of land classes and their locations have varying suitability for freshwater as well as brackish water aquaculture. While this land classification is extremely important to assist in siting of farms, a more important issue - which impacts on investments - is land tenure. About 87% of land in Fiji is under customary ownership of the indigenous community, and part of this is leased, to farmers, through the Native Land and Trust Board. The length of lease and the security of tenure are very much part of farmers first decisions affecting investment in farming, together with investment in durable physical assets and farm improvements. Land-leasing arrangements are politically sensitive and a longstanding issue of contention in the government.

II. Background information

The history of aquaculture in Fiji, began with the introduction of the *mossambique* tilapia for mosquito control in the 1950s. The following historical information is drawn from the Aquaculture Country Profile 2002 prepared by Satya Nandlal for the FAO Sub-regional Office for the Pacific Islands and the Department of Fisheries.

Tilapia (*mossambicus* species) was introduced in 1954. It was also used to support diets for pigs. It escaped into the river systems and became an important source of animal protein for those living beside those water systems, but subsequently turned into a pest.

In 1971, a newly reclaimed mangrove land of about 39 hectares (in Raviravi) was set aside for the trial of several brackish species including signaids, milkfish, mullet and shrimp. This was assisted from funds and technical expertise of FAO. A biological problem was posed by the proliferating and brackishwater-adapted *Mossambique* Tilapia that would come in with the pond water. In 1973, *O. niloticus* was introduced from Israel for trial in the ponds at Raviravi. The two species interbred and the offsprings soon dominated the water systems. The remaining stock of *niloticus* were transferred to Lami then to Naduruloulou aquaculture station in 1980-82 but it was difficult to maintain the strain as the surrounding waterways were full of the mossambicus. In 1988, the Chitralada strain of *niloticus* was introduced from Thailand which lost no time interbreeding with the other two species. In the same year, the GIFT tilapia, a genetically improved strain of tilapia, was introduced from the Philippines.

Carps were introduced from India 1975 for the control of water weeds that have been choking the river systems and channels. The fish cannot breed in captivity and the river systems in Fiji are too short for the fish to successfully breed as it takes 18 – 24 hours for the eggs to hatch. In 1976 the Naduruloulou Freshwater Aquaculture Station was established and the carps and tilapia were transferred there. There were subsequent species of other carp introduced from Thailand, Korea, China, etc. The breeding stock was built up and fingerlings were released into the Rewa River, the major river.

In 1982, the US Peace Corps and the government initiated the Rural Aquaculture programme which established fish farms in inland areas.

Black Bass was introduced in 1984 from New Caledonia for stocking in the newly built Vaturu reservoir in the hills of Nadi.

Between 1984 and 1989, the JICA-assisted R&D project based in Naduroulou included the breeding of grass carps and introduction and breeding of silver and big head carps for farming. Over the project period, several introductions were made from Japan. One unfortunate biosecurity breach was the accidental introduction of the garden snail that would become a pest in the ponds. The carp was successfully spawned and breeding of the carps at the Naduruloulou station has been successful and the fish produced on demand. Meanwhile, the grass carps cleared the water bodies of weeds.

Macrobrachium rosenbergii was introduced in 1980 from Hawaii by an officer with two other Fijians after their training. The JICA-assisted R&D project successfully spawned the species. This catapulted the giant prawn into one of the important species for aquaculture in the country. Research by USP and the Naduroulou Station subsequently improved the breeding and culture technology; the research included performance evaluation of the various strains introduced later from Southeast Asia.

Ornamental fishes (goldfish and koi carp) - There have been introductions of the ornamental fishes from the colonial era for home aquariums by hobbyists. In 1993 the Ministry of Agriculture, Fisheries & Forest considered ways to centralize the importation for control on possible introduction of diseases etc. Only three importers were allowed to bring in their nucleus stocks for breeding. The companies were active only for a few years which led to the Department of Fisheries taking over breeding and supply; it moved stocks in 2002 from a local farm as well as introduced more stocks from Malaysia to the Naduruloulou station. The Department has demonstrated that ornamental fish can be a cash crop as it has a good local market. Promoting its integration in other agriculture or aquaculture enterprises or polyculture with other species is being initiated.

P. monodon is found locally and the attempt to culture it began in 1973 with trials at Raviravi with FAO assistance, which lasted for 5 years. In 1982 commercial culture of the species began. A hatchery was established and the Raviravi farm became the first commercial shrimp farm in Fiji. The owners were the Government and Aquacop of Tahiti. Technical difficulties arose in commercially producing seed of the *P. monodon*, so the Latin American native, *P. stylirostris*, was introduced in 1984. In 1990, an Australian group took over the farm and focused on *P. monodon*. In 1991, the management at

Raviravi assisted another farmer by establishing the second commercial farm on the farmer's property in Navua on the Eastern side of the main island of Viti Levu. Soon after however, the Raviravi farm was closed and sold by the Australian owners. In 1998, the Department of Fisheries established a hatchery in Navua area to serve four commercial shrimp farms established there. It started with *P. monodon* but lack of success led it to change to *P. stylirostris* in 2006. A batch of *P. japonicus* was introduced in September 2006 and successfully spawned at the hatchery. A partnership company took over, to commercially operate the hatchery from November 2006.

Milkfish (*Chanos chanos*). After over two decades of on and off culture trials in Raviravi, the government in 1998 considered widespread farming. The major objective of farming was to produce bait in the tuna industry. It was established that around 80% of fish fry along the coasts (inter-tidal area) of the two main islands were milkfish. A 50-acre (20ha) farm was established on Vanua Levu, the second largest island. The farm suffered during the political crisis in2000.

Kappaphycus seaweed was introduced in 1982 by a New Zealand company. After a promising start, the culture of this seaweed faced many problems and ceased in 1987. In 1998, the government resumed the farming of this seaweed. It has not attained the commercial scale that was desired but it continues to be encouraged by government.

Black-lip pearl oyster (*Pinctada margaritifera*) was introduced by a Japanese operator in the early 1950s. It was only in 1998 that government promoted its culture. A number of private operators ventured into pearl farming. Marketing efforts for Fiji pearl began in 2005, mainly to Japan. One company attained success in farming and marketing pearls.

Giant Clam culture began in 1984 with the support of an ACIAR project that proposed to study the level of the wild resources in the country. The project has been maintained for various purposes including reef reseeding and the aquarium trade. Spawning of trochus was done with the giant clams as the facilities were suitable for both species. Fiji provided neighboring countries with trochus for their reseeding purposes. Trochus shell is mostly exported.

The study came up with a number of conclusions and recommendations. The ones that the mission considers relevant today are reiterated in the lessons and conclusion of this report.

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indications for the mission to follow up;
2. Regional and national reports and assessments relevant to fisheries and aquaculture of Fiji.
3. Face to face interviews with key informants; these included policy, management, and technical personnel in government agencies, academic institutions, development and pilot projects, and private enterprises. The list of persons met appears as Annex 1.
4. Visit to projects, farms, R and D stations, hatcheries and ornamental species production and export operations.
5. The 1984 review of aquaculture in the Pacific Island region by the Pacific Islands Development Program, East West Center, Hawaii.
6. Initial report of the inventory of aquaculture farms carried out by the aquaculture division, Aug. 2010.

IV. Findings

This mission report provides indicative and broad findings. The findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. A draft decree governing fisheries - offshore, inshore and aquaculture - is under review through a series of stakeholder consultations; at the time of the mission the aquaculture section of the decree was on its second revision. Heretofore, aquaculture has not been governed by a distinct legislation. One of the important issues it seeks to resolve is property rights and access, the purpose of which is to encourage investments by guaranteeing tenure.
2. The government was discussing a strategy to "industrialize" aquaculture looking at some structural models to bring this about such as the "satellite" and the "cluster" models.
3. There is also an expectation that the new law would wean the sector away from heavy government subsidy, particularly finfish and crustacean farmers. Other than pearl farming, farmers are provided seed, feed and even harvesting facilities by the government, so an appropriate sector development model is important.
4. The freshwater aquaculture sector development strategy and plan for the period 2005-2010 is under review.
5. To provide information for the review and for the consultations on the aquaculture law, a survey of farms was launched at the time of the mission.

2. Aquaculture initiatives and impacts

The species (and systems) that have been initiated in Fiji, and a brief description of their results are described in the table below.

1.	Tilapia (*O. niloticus*). Introductions and performance trials of various strains of the niloticus species , by the government and the University of the South Pacific has provided a reliable seed source and technical information for the widespread promotion of tilapia mainly for semi-commercial and subsistence farming. However, there are some farms that sell excess output in the locality itself, by the road, or in neaby urban markets. Tilapia is mostly cultured in small family-run ponds and in school ponds. The development of a feed support sector has generally not kept pace with the expansion of tilapia farming, but feed formulation and nutrition studies are going on.
2.	*Macrobrachium* sp. (*M. rosenbergii and M. lar*). Research and development on giant freshwater prawn has covered the range of technical issues from ecology, population genetics, domestication, broodstock development, hatchery, culture and post harvest handling. The exception is marketing. The long and sustained R&D effort has provided a reliable technology base for its commercial culture. Government and a private hatchery demonstrate the feasibility of mass seed production for an expanded and commercial scale prawn culture industry. The current diet formulation and nutrition research project based on locally available ingredients should provide a technology package for the establishment of a prawn and fish feed industry should the sector expand. At the very least, it could provide a basis for farm-made feed formulations that a commercial scale operation may wish to integrate, or for a farmer association or farmer cluster to collectively operate.
3.	Integrated farming (fish- poultry and livestock). R&D and demonstration by the freshwater aquaculture research station in Naduruloulou has shown its technical feasibility. An institution-operated farm (under the the Monfort Boys' Town) has adopted the system in a scale that is much larger than a family operation, and has shown it can be sustainable. The farm's harvest is not marketed; it is for the students and staff.
4.	Grass carp. Introduced to suppress water weeds that had been choking waterways (with effective results), grass carp is now one of the species in monoculture and polyculture pond systems. The Naduruloulou Research Station mantains stocks and produce seed for farmers. Other species of carps (silver, bighead, black, and the other Indian major carps) have been subsequently introduced.

5.	Corals and "live" rock. The harvesting and eventually culture of corals was driven by trade and is private-sector led. In Fiji, there is really only one major player, the Walt Smith Company. Strict regulations on harvesting and environmental impacts as well as workers' health and safety compelled the private sector to find ways to harvest sustainably, to select and develop "broodstock" and to culture hard and soft corals. These also highlighted the importance of training, protocols and equipment that mitigate health hazards as well as improve workers' efficiency.
6.	Seaweed. The waters and other biological and physical attributes of Fiji are very favourable to seaweed culture. The technology is available and there have been pilot commercial projects. At the time of survey however, there was no sustained seaweed production in Fiji. A pearl farm has showed interest in integrating seaweed culture in its leased water areas. As there is no processing plant in the Pacific, the issue remains to be competitiveness and cost of transporting a low value, high volume commodity to a distant processing plant.
7.	Milkfish. A demonstration project with social objective, i.e. demonstrate the feasibility of low-input, low-tech milkfish farming to the people that cannot afford the high priced sea fish. The goal is to enable them to eventually take up milkfish pond culture as a rural livelihood activity to produce low cost fish and earn some income. The project is well planned but it is beset by many problems that include the natural (high salinity and high temperatures due to a drought), physical (poor soil structure) and biological (inability to produce a plankton mat for fishfood and the threat of tilapia infestation). There is also need to improve the technical skills of the farm workers.
8.	Giant clam. It is doing well as an aquarium species. Seeding the clams in marine protected areas so that they are protected by the people and can grow to maturity appears to be a promising strategy.
9.	Marine shrimp. Technically and economically, a government–initiated marine shrimp project, that was spun out to subsequent private investors were a success. It was reportedly problems of financial management that did harm for the project. The marine hatchery in Galo is being renovated to produce better quality shrimp seed, and other species such as sea cucumber for enhancement.
10.	Pearl oyster (*Pinctada* sp). One high performing pearl farm and a smaller farm that has sustained its operation over several years despite many constraints provide instructive lessons in farm management, innovation, corporate social responsibility, marketing strategy, and resilience. As a whole, however, pearl farming in Fiji has not expanded beyond these two farms.

3. Lessons

The lessons from the previous and current aquaculture initiatives are based on the analysis of the important farming system/species using an analytical framework that focuses on the feasibility issues of farming or producing the species, namely biological, technical, economic and social. (The logic of this scheme appears as Annex 3 of the Synthesis). The analysis for the important and potential species using the above scheme appears as Annex 2 with tilapia as an illustrative example. The other species in the list of examples are freshwater prawn, pearl oyster, grass carps, milkfish, and marine shrimp. Seaweeds have been grown before and remain to be a potential commercial crop. This is not analysed for Fiji because its feasibility issues are already well illustrated in the other country reviews.

3.1. General lessons

The general lessons that have stood out on the keys to success in the development and adoption of a species for aquaculture are the following:

3.1.1. The early establishment and strengthening of a freshwater hatchery, which subsequently developed into a research and development station, gave a headstart for a well-organized adaptive research;

3.1.2. Training of researchers and technicians in local and regional programmes that are practical and production oriented produced a wide personnel base with sufficient skill for research,

training, extension and production. Training included those of FAO through the South Pacific Aquaculture Development Project (SPADP), SPC, USP and NACA.

3.1.3. The focus of (freshwater) R&D on two species, tilapia and *macrobrachium*, which concentrated research efforts on essential and priority problems especially seed production, culture and feed and nutrition;

3.1.4. The weak motivation for farmers to farm better and the strain that it is exerting on the capacities of its R&D facilities are a signal for government to move away from supplying seeds to commercial farmers and focus on training some farmers to produce their own, or to encourage and support with commercial incentives a producers' seed production and distribution venture. Seed production and supply continues to be an important function of the public hatcheries and research facilities;

3.1.5. Due to the complex village and social demands, fishponds are not adequately managed, as farmers become involved in other traditional activities. There is a need to spend the greatest amount of effort on farmers who have the highest level of motivation and those with the greatest potential for success. More successful farms can be used as model and demonstration sites for emerging entrepreneurs. Selection of model farmers is important and must be done with foresight (FAO 2002).

3.1.6. One technical reason for past aquaculture failures Fiji is the high cost of imported feed and the non-availability in the domestic market of feeds, especially for farmed shrimp. The FAO study of 2002 suggested that the production of high quality commercial formulated feed needed attention that would include promoting a private feed industry (FAO 2002).

3.2. Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the species in Annex 3.

3.2.1. Strategic:

- The contribution of the SPADP to the expansion of aquaculture activities in several Pacific island nations including but especially Fiji, where it was based, was significant in several ways: the value of a planned and systematic research and development programme was infused into aquaculture; initiating the link between Pacific and Asian aquaculture; and bringing aquaculture into greater attention in national planning.
- Government-academic partnership in developing an aquaculture strategy, planning and implementing research and technology development contributed to the strengthening of the government capacities, informed the academic programmes with practical field problems, and provided a training opportunity for students of fisheries and aquaculture.

- The government's socially oriented policy to promote aquaculture as a rural activity for food security and income had effectively accomplished its immediate objective: aquaculture, especially freshwater aquaculture, became popular and gained a fairly widespread adoption. The heavy subsidy of inputs, which was the cornerstone of the policy, is now seen as counterproductive from an economic standpoint. It is also technically difficult to sustain.

1.1.2. Management:

- There is a sense of urgency to test suitable models of commercial aquaculture development. One existing model, exemplified by the pearl farm in Savusavu offers one valuable lesson for success: part of a good marketing strategy is an image of corporate responsibility which can be achieved by a code of practice - but this has greater relevance to export species. A second arrangement could be a satellite scheme developed around the freshwater prawn farm being operated by USP experts under a business-academic collaboration with the Dairy Farm of Fiji. The farm which has a hatchery and grow out ponds could supply seed and technical expertise to smaller farms clustered around it. A cluster of small farms served by a dedicated commercial hatchery and a commercial feed supplier can be another model if there can be enough farms that are located close to each other to be organized into a cluster or an association. A third model could be contract growing. A fourth model is the one suggested by the milkfish demonstration project: it is essentially a medium scale community–managed production system that will

provide the fish supply to the community, in this case, families of plantation workers that have established settlements in rural areas. Any one of these could be suitable under certain social and economic circumstances or agro-ecological conditions.

- To support the seed requirements of any of these models, the survey has identified decentralizing hatchery operations as an option. This would require focused training and technical assistance on hatchery management and operation, health management, and a good seed distribution system. A decentralized private hatchery system would enable the government to focus its efforts on improving and maintaining the broodstock and on research.
- The aquaculture sector has a fairly strong research and training service which is also tasked with extension, a latent credit sector that could likely be mobilized for lending to commercial fish farms, and national transport and market infrastructures that are fairly efficient. These services can efficiently serve a commercial aquaculture industry. Unfortunately the supply input service is weak, due to a lack of a sizeable commercial volume that can attract private investors. If the government wishes to empower this sector, it should encourage it with the appropriate policy and incentives but avoid competing with it once established.

1.1.3. Technical:

- The production and improvement of quality of inputs through research are now the premier technical objectives of the government R&D stations and the academic institutions, notably USP. The government can encourage the establishment of a commercial, private-led seed production and feed supply sector that can make use of the technology developed from the government and USP research.
- Market research and development is a high priority task for government with collaboration from the private sector and the academic institutions. It would include product development and promotion and the improvement of food safety standards.
- Local market development is critical for the commercialization drive. As shown by the survey some farmers (tilapia) are now selling extra produce in local markets, by the roadside, and in nearby urban markets. The more remote ones are at a disadvantage because of the cost of transporting the fish (which in volume may not be large in the first place). All the farmers would benefit from either a cooperative marketing scheme or a bulk-buying scheme. There are bulk buyers for freshwater prawn, which is a more expensive commodity and therefore more attractive for middlemen. A bulk buying scheme for a lower cost and more bulky product like tilapia or carps would need to be at an economy of scale, which requires (a) a reliable supply from regular harvesting; (b) a large enough volume; and (c) a good communication link between farmers and buyer/s. Organizing the farmers for cooperative marketing is an option.
- Investments in commercial ventures will need a reliable and reasonable credit support which the Fiji Development Bank could provide, as it has done so with previous commercial ventures. This would need government assurance as the Bank has previously lent money to mostly discontinued commercial ventures.
- A programme for upgrading of skills for the aquaculture staff is essential particularly the newly recruited staff and farmers. The recent survey showed that the farmers who were trained did much better that the others.
- Finally, the culture of freshwater ornamental species, in particular koi carps and goldfish, which have a promising local market can, could be promoted for peri-urban aquaculture. It is now being cultured with other carp species and could be developed into a cash crop for small subsistence farmers in rural areas.

V. Conclusions

A long period of sustained R&D work has laid down a strong technology base for aquaculture development. Government-academic alliance, made possible with the presence of a center of excellence, (the USP in Suva) has been a strong impetus to technology and manpower development.

This has facilitated and increased the value of assistance from donors and development assistance agencies such as ACIAR, JICA and FAO, and regional organizations such as SPC and NACA. Fiji has a wide and skilled manpower base for the scientific, technical, management and extension functions

in aquaculture. Labor cost is not as high as some other Pacific island countries. These are some of the attributes that give it a competitive edge over other neighbors.

The government's policy has been socially oriented: it focused on enabling small rural households (and schools) to produce fish for consumption by extended families and schools. The excess harvest would be sold to earn some income. This was the aim of the promotion of tilapia culture. However, there was no distinction made for the higher value species such as freshwater prawn and marine shrimp. It evolved to such a point that the government aquaculture section and stations were saddled with the task of producing and supplying seed and feed (as well as lending equipment and assistance for harvesting) of tilapia, prawn and shrimp to every fish farmer in Fiji, for free. While the number of farms is not large i.e. around 300, this is not a function that a government aquaculture unit should be perpetually doing. The task now is not only to develop an industry structure that supports Fiji's aspiration to emerge into commercial aquaculture development, but the more difficult task of persuading farmers - already used to the heavy subsidy - that it is in their interest to become more self-reliant. The interim approach could be a dual model by which government continues to provide the same subsidy to the poor very small scale farmers producing fish for extended family subsistence and developing a satellite or cluster model for marine shrimp and freshwater prawn farmers, who are invariably better off and whose products have a good price in the domestic market, and who now benefit from the services of a bulk buyer.

The pearl farming sector is made up of practically only two players, the major one being the JH Pearls in Savusavu and the long time and sustained but smaller one being the Tokito Pearl Farms in Raki Raki. Their operations are socially and environmentally responsible. They have worked out lease arrangements with the communities that are mutually beneficial. They have established their markets. Their risks are mostly from natural hazards particularly cyclones. But, their fear is the commoditization of the South Sea pearl, which has a high value as a luxury product. Commoditization can happen with an influx of investors and if quality is sacrificed for quantity. Entry is not easy, however, because of the capitalization and level of skill required. While it is not heavily regulated as an industry, environmental regulations and community expectations of the pearl farms (which need fairly large water areas traditionally under the ownership of communities) do not make it easy for prospective investors. Nonetheless, government and the private sector would need to balance the risk of commoditization (which means a debasement of the perceived value and inevitably the price as well as market of the product) with the benefit that more pearl farms could bring to the communities.

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Annex 1

Persons Met in Fiji Islands

1. Commander Sanaila Naqali, Director of Fisheries

2. Gerald Billings, Principal Fisheries Officer and Head of Aquaculture gerald_billings08@yahoo.com

3. Ms Tavenisa Vereivalu, Aquaculture Section, Lami Office

4. Anand Prasad, Fisheries Technical Officer, Galoa Aquaculture Center prasadanand09@yahoo.com

5. Ms Mere Siqila-Lakeba, Aquaculture Officer, Naduruloulou Aquaculture Research Center

6. Malelili Dawai, Supervisor, breeding programme, Naduruloouu Aquaculure Research Center

7. Brother Thomas Kottarathil, Director Montfort Boys' Town, Suva suvakm1976@yahoo.com, Tel 3361433/ 3361363

8. David Oliver, Managing Director,Aquarium Fish Fiji, Co. Pacific Harbor affc@conncect.com.fj

9. Avinash Singh, Fellow, University of the South Pacific Institute of Marine Resources, Technical Manager, Dairy Farm Fiji Aquaculture Project, avinash.singh@usp.ac.fj

10. Chris Turnier, Pacific Aquarium Farm, Walt Smith, Lautoka, chris@waltsmith.com

11. Hideyuki Tanaka, Project Manager, Milkfish Farming Demonstration Project, Raki Raki

12. Mr. Tokito and son Kenji, Tokito Pearl Farms, Raki Raki

13. Justin Hunter, JH Pearls, Savusavu jhunter@pearlsfiji.com

14. Timothy Pickering, SPC Freshwater Aquaculture Specialist, USP Campus, Suva timp@spc.int

Annex 2

Feasibility issues of selected species and their farming systems, Fiji Islands

1. Tilapia (*O. niloticus*)

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	The *mossambicus* species became a pest but it also pointed to the possibility of farming tilapia for food. When improved strains became available Government's desire to improve the quality of the tilapia species for farming led to its introduction.	*Private/commer-cial feed and seed supply sector is absent.*	Promotion of the culture of tilapia for food security and income generation has facilitated its adoption.	Government's social oriented policy to promote rural aquaculture enabled a wide adoption of the tilapia for pond culture in small farm holdings and schools.
Research	Introduction of improved strains such as GIFT and Chitralada upgraded the stock.	Development of an integrated farming system of tilapia and crops; continuing stock improvement and performance trials of different strains; The continuing trials on performance of different strains and feed formulations provides the technology that a feed industry could subsequently use. *Need to improve the efficiency of the tilapia/ carps and carps/prawn polyculture systems*	*Commer-cialization objective requires a reliable marketing system; there is a need to explore convenient and reliable marketing options for farmers.*	
Extension		A good training programme has been developed for freshwater aquaculture and available at the Naduruloulou station		*A heavy reliance on government assistance has not encouraged the development of technical and management skills among farmers*
Institutional collaboration & partnerships		USP, SPC and government collaboration in research and training; USP students conduct research and farm practice in government station.		
Market development		*No bulk buyer of fish, because of lack of reliability of bulk harvests ; need to explore cooperative marketing by farmers*		Accepted by population; fairly sizeable local markets in 2-3 urban centers on the main island.

Keys to success	A sustained R&D on tilapia and technological back up to farmers from the government research station.
Key Constraints	*Lack of quality feed, management skills not widely acquired or with little incentive to be acquired due to the heavy reliance on government material and technical assistance by farmers.*

2. Giant freshwater prawn (*M. rosenbergii/M. lars*)

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/ regulations		Government allows importation of *M. rosenbergii* strains only for R&D purposes.		
Research	Exploratory studies on *M. lars* by USP as a second species for culture.	Extensive research studies done in USP and government centres from seed production to culture.	*Cost and return analyses are rarely included in the R&D projects thus no economic and financial guideline for investors.*	
Extension		Free provision of seed and feed. Technical advice from government officers and USP researchers.		
Institutional collaboration & partnerships		A joint project of USP and a private commercial farm is providing a good example of a viable commercial operation. USP students conduct research and farm practice in government stations.		
Market development		A good transport and market infrastructure	Bulk buyers now serve the farmers Promoted and geared to tourism industry	
Keys to success	A good local market and price for freshwater prawn; research and development including trained researchers in USP and adaptive research in government research station has built up a stock of knowledge, technology and expertise for freshwater prawn research and technology development			
Key constraints	*Relatively low adoption despite government support; occasional but severe natural hazards like floods.*			

3. Pearl oyster (*P. margaritifera*)

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/ regulations	Conservation and protection of seed sources; Fiji pearl oyster species promoted for culture.	Environmental regulations including sustainable harvesting of spats are stringently enforced.		Code of practice developed and adhered to by pearl farm.

Research		Pearl farming skills brought in by the two entrepreneurs/ investors; technology from other Pacific countries well known.		
Extension		Nuclear implantation expertise brought in by technicians; hatchery technology developed for own use by one of the farmers.		
Institutional collaboration & partnerships		USP student researches (such as performance of hatchery vs. wild spats; and seed resource assessments) conducted in the pearl farm.		
Market development		Japan was the first target market; this subsequently expanded to other global markets	Pearl companies launched their own promotional and marketing campaigns.	Code of practice assures corporate social responsibility and improves image of the farm and its product.
Key to success	Sustainable production and environmentally and socially responsible farming practices; good relations and shared benefits with the community; a high-fashion promotional and marketing campaign.			
Key constraint	*Commoditization of the South Sea pearl is a risk to its image. Occasional but severe natural hazards (cyclones); a long-term risk is acidification of the sea.*			

4. Milkfish

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Milkfish occurs in Fiji waters and its culture for bait was the initial purpose of farming the species.		Government support for the milkfish pilot project as a food security option for low-income rural communities.	
Research	*Threat of tilapia infestation*	*Technology and skills for the natural food production (of lab-lab or phytoplankton mat) suitable for the pilot project is lacking.*		The current pilot project with JICA assistance attempts to demonstrate a community managed food production operation with food security as a main goal.

Extension		*Workers' skills are in need of much upgrading*		*Eventual takeover by the community of the management of the project depends on its demonstrated success now, which is jeopardized by the many technical problems.*
Institutional collaboration & partnerships		JICA-Government cooperation in implementing the pilot community project.		
Market development				
Key to success	Community and government support; a dedicated project coordination and management.			
Key constraint	*Management and operation skills of the farm workers are inadequate.*			

5. Corals

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Environmental regulations are clear and adhered to by operators		Trade is supported by government.	Community jurisdiction over the waters assures they benefit from the trade in corals.
Research	Identification and selection as well as conservation of coral broodstock.	Development of better hatchery technique.		
Extension				Safety Measures And protection of the health of collectors have been improved by technology, regulations and training of divers & collectors.
Institutional collaboration & partnerships				
Market development			A regional network of coral production, and export centres and a global market has been developed by the largest coral producer and exporter in the Pacific, Walt Smith Co.	
Keys to success	A growing aquarium trade. Better hatchery techniques. Assurance of community benefit and better community relations.			
Key constraints	*Acidification and warming of the waters is a long term threat; a medium term threat is the saturation of the market.*			

6. Carps

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulation	Introduced for weed control which turned out to be a success			Carps were an acceptable food fish to the population.
Research	Introduction of other carp species that became culture species for food. *Threat of mossambicus infestation of*	Spawning was successful and integrated culture.		
Extension		Promotion of polyculture system with freshwater prawn.		
Institutional collaboration & partnerships		JICA assistance to introductions and research on breeding.		
Market development				
Key to success	Acceptance as a food fish and its success in weed control made carps a favoured species; successful spawning provided the prospect for a reliable mass seed production and supply			
Key constraints	*As most of the carp species introduced do not spawn naturally or cannot spawn in the short river systems, lack of a decentralized seed production and supply slows down wider farming.*			

7. Marine shrimp

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Government started P. monodon (which occurs in Fiji) hatchery and culture; initiated importation of other species.	Government established the hatchery and built experimental and pilot commercial farms. *Biosecurity measure needs strengthening.*		Areas set aside for shrimp farming were not critical wetlands. No conflict was generated from the opening of the reclaimed mangrove.
Research	Galo station diversified into another indigenous species, *P merguiensis* as an alternative culture species.	Culture trials established the technical feasibility of farming either *P. monodon* or *P. stylirostris*.	*Producing for the export market apparently failed to consider competitive advantage.*	

Extension		Galo station is being renovated and strengthened for marine species (shrimp, crab and sea cucumber) seed production.	As of today, government continues to provide free seed to the one farm left producing shrimp.	
Institutional collaboration & partnerships				
Market development			Local demand and purchasing power are high but for a limited volume.	
Key to success	Presence of indigenous species; well-known technology for shrimp seed production and grow out culture.			
Key constraint	*Market. Local market would be limited and shrimp would likely compete with the freshwater prawn; export market in the region (Oceania) is now highly competitive with a sizable production from New Caledonia not to mention the advantage of Asian shrimp.*			

Country 6

Tonga
24-28 August

I. Introduction

Many types of aquaculture have been tested in Tonga, mostly through government programmes with external support. However, research results have not been scaled up to commercial level. A recent attempt is *Pteria penguin* for production of half pearls or mabe, which a few small farmers are culturing on the island of Vavau.

Two sources of strength of Tongan aquaculture are its aquaculture legislation for the aquaculture sector and the well-equipped and modern Sopu Mariculture Centre. The Aquaculture Management Act was passed in 2003 and has clear provisions for regulating, managing and developing the aquaculture sector. It includes access rights and licensing. To achieve the purposes of the Act, the Tongan government with assistance from SPC has formulated the Aquaculture Management and Development Plan and a more specific Aquaculture Commodity Development Plan for 2010-2014. The Sopu Mariculture Centre has been the location of national aquaculture research activities since the early 1960s. The modern facility was set up with assistance provided by the Australian Centre for International Agricultural Research (ACIAR) and then by the Government of Japan. It is a multi-species hatchery. Research, training and production of seed for grow out trials and for commercial production are conducted in the centre.

II. Background information

Legal framework. The main laws related to fisheries and aquaculture in Tonga are the Fisheries Management Act 2002 and the Aquaculture Management Act 2003. The major provisions and features of the Aquaculture Management Act 2003 [3] include the following:

- The Minister shall be responsible for the control, management and development of aquaculture and any related activity, whether on land or in any aquatic area including marine areas.
- Aquaculture management and development plan: The Minister shall prepare and keep under regular review a plan for the management and development of aquaculture which shall be published in the Gazette.
- Codes of practice: The Minister may, in consultation with the Aquaculture Advisory Committee, issue and publish codes of practice. The Minister shall ensure that a copy of every code of practice is available for inspection by the public during business hours and copies of the whole or any part of that code shall be provided, upon payment of the prescribed fee. The failure to comply with a code of practice shall be taken into consideration in the grant or disqualification of any authorisation under this Act.
- Aquaculture Advisory Committee: There shall be established an Aquaculture Advisory Committee to advise the Minister on policy, planning and guidelines for the regulation, management and development of aquaculture; and any matter on which the Minister or the Secretary is required to consult the Advisory Committee under this Act.
- Aquaculture and related activities shall only be conducted by persons who hold an aquaculture development licence or other authorisation issued in accordance with this Act; within aquaculture areas.
- An aquaculture development licence: shall be valid for the period stated in the licence which shall not exceed 10 years; shall not be used for any purpose other than those purposes specified in the licence; and shall be subject to any general terms and conditions which may be prescribed generally or in respect of the relevant type of aquaculture by regulations.
- Environmental impact assessment: Holders of an aquaculture development licence or other authorisation shall take all reasonable practical measures to avoid or minimise pollution and any harmful environmental impact caused by aquaculture or related activity, including the discharge of effluent and the disposal of sludge.

[3]An amendment to the Aquaculture Management Act 2003 was made in 2005; the words "or the Waste Management Act 2005" were inserted.

- Exotic fish: The Secretary may designate any species of exotic fish and such designation of exotic fish shall be published. No person shall introduce or import, possess, culture, sell or export any exotic fish without the written authorisation of the Secretary.

National goals for aquaculture. The goals of aquaculture set out in the development plan are to provide food security and employment, earn foreign exchange, reduce pressure on inshore fisheries, and promote stock enhancement of over-harvested fisheries.

Constraints. The achievement of these goals faced constraints that include lack of technical expertise, social problems that discourage investment, natural disasters, and recently the rising seawater temperatures. The latter is particularly unfavorable to *mozuku* seaweed culture.

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indications for the mission to follow up
2. Tonga Aquaculture Commodity Development Plan, 2010-2014
3. National and regional reports relevant to fisheries and aquaculture in Tonga
4. Personal interviews with key informants: these included policy, management, and technical personnel in government agencies, members of the Tonga Fisheries Industry Association, and private entrepreneurs. The list of persons met is Annex 1.
5. Visit to projects and the Sopu hatchery.

IV. Findings

This mission report provides indicative and broad findings. The findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

Kingdom of Tonga
1. Tonga has in place all the essential policy, regulatory and management mechanisms for aquaculture development. Listed below, these have already been described in the previous section. ▪ Aquaculture Management Act ▪ Licensing requirements ▪ Aquaculture Regulations 2008 ▪ Aquaculture Commodity Development Plan 2010-14 One area that is seen to need strengthening is staff development for research and extension and training of farmers. 2. A feature of the law of Tonga is its provision for open access to all water bodies which is considered as a disincentive to resource conservation and management by the communities. This prompted the government to establish eight special management areas in strategic sites of the three main islands, Tongatapu, Hapa'ii and Vava'u. This however does not affect coastal aquaculture. 3. A recent plan to raise the rent tax for extractive activities such as capture fisheries and collection of corals and live rocks (except the harvesting of sea cucumber) may encourage some of the fisheries business people to diversify into aquaculture.

2. Aquaculture initiatives and impacts

Over a 50-year period, there has been a wide range of species - finfish, invertebrates, molluscs and plants - that have been studied and tried for culture. The results have been mixed but generally none has made it past the pilot stage and the few that did, could not be commercially sustained. Some of the species (and systems) that have been initiated in Fiji and a brief description of their results are described in the table below.

1.	Mullet in pens in the lagoon. Culture period of native mullet species was too long to make it attractive to farmers; poaching was a problem. Imported mullet has a lower price than the two native mullets.
2.	Giant clam. The original purpose of growing it for food and for restocking was subsequently supplanted by the objective of growing it for aquarium trade. There is some success in the stocking of clams in special management areas for the same reason as Fiji's i.e. the stocked clams are protected by the people. The hatchery has also provided stocking materials to Samoa, in 2006 and 2007 (1000 seeds mostly of Tridacna gigas).
3.	Pearl (Pteria for mabe production). Hatchery production of seed is successful and a few farmers have established Pteria culture farms; the effort is recent and the status is being monitored.
4.	Mozuku seaweed. Culture was successful and harvests of 300-400 tons a year were initially recorded, but the market went flat. The claim is that there is enough mozoku seaweed in the wild to fulfil the demand for natural mozuku processed into health care or health enhancing products. Culture has ceased. Post harvest handling which requires refrigeration is costly because of the high cost of energy.
5.	Sea cucumber. Seed production for stock enhancement has been initiated; this is seen as urgent because the harvest and export have been intensified with the lifting of a 10-year ban on collection.

3. Lessons

A background to this section is provided by a historical note on the results of R&D efforts in Tonga. Aquaculture research has been carried out in Tonga for almost 50 years, mostly by the Fisheries Division, with extensive support from a wide range of foreign aid donors. The research carried out has mostly been biological in nature and has covered a wide range of aquaculture candidate species including finfish (tilapia, mullet, mollies, milkfish), molluscs (edible oysters, pearl oysters, mussels, giant clams, green snail, trochus) and seaweeds (*Eucheuma* and recently mozuku seaweed *Cladosiphon* spp.). Little economic development has resulted from this work, although there are some promising avenues.

The analysis on the feasibility of the important and potential species appears as Annex 2, with mozuku seaweed as an illustrative example. The other species is mullet. Pteria penguin (for mabe pearl) and giant clam are important species but the feasibility issues of pearl oyster farming and giant clam are already well illustrated in other country reports. Sea cucumber seed production is a recent initiative to which a sizeable resource of the Sopu hatchery has been set aside in view of the urgency and importance of stock enhancement. A notable plan of the aquaculture division is to engage the partnership of the sea cucumber companies in the reseeding for which the companies will pay for the seed and technical service and, of course, protect and manage the seeded stocks.

3.1. General lessons

What has stood out as a good lesson for the development and promotion of a species for aquaculture is a commodity action plan that has clear statements of outcomes; it is results based. It is based on thorough study of the biological and technical feasibilities and its economic viability. This was done with the initiative to culture mozuku seaweed. A FAO technical cooperation programme (TCP) project provided the technical assistance to the study and the start up of the culture trials. Assistance subsequently included training of farmers and workers on the entire range of technical and management

work needed to grow, harvest and handle the material after harvest; establishment of a pilot culture project, processing and marketing, and then product promotion. The outcome of the project was the successful establishment of mozuku farms, production of a commercial volume of seaweed, and export of the material. The technical and commercial objectives of the project were realized. It was not however sustained, and the reason for this provides another set of useful lessons: the market was volatile and limited to one country (Japan) and the Tongan product suffered from lack of competitiveness due to the high cost of transport and a limited range of product forms that were developed and offered to consumers. Post harvest costs, especially refrigeration, are high because of the high cost of electricity and fuel.

3.2. Specific lessons

The specific lessons are classified into strategic, management and technical lessons and are drawn from the feasibility issues related to the species in Annex 2 and from the information on the farm trials of pearl oyster, production of giant clam seed and early attempts at producing seed of sea cucumber for stock replenishment.

3.2.1 Strategic:

There is a common agreement that much of the R and D results have not been upscaled into sustained production systems, much less into commercial level operations. The above-discussed example provided by mozoku seaweed is an exception. It moved from research to pilot to commercial scale operation, but then met with market constraints. This lesson points to the importance of commodities for the local market, which by itself is also limited. The indigenous mullets would have served this purpose except that they also met technical, market and social constraints. These various problems, which span the range of biological-technical-economic-social feasibility issues, seem to provide the excuse for the lack of progress of research results beyond the pilot stage. These also underline the need for a closer partnership between the government and the private commercial sector at the pilot testing stage of production systems at the least. Limited discussions with representatives of the Fisheries Industry Association highlighted this observation of lack of upscaling but also their desire to be involved in aquaculture R&D. This was due to an interest in diversifying from capture fisheries to aquaculture. For a start they are keen to know and apply technology already available from the fisheries department in pilot commercial operations. One fishing company executive would like to try sea cucumber, another would want to include the culture of *Kappaphycus* in his operations to be farmed in small plots by the family of the workers.

3.2.2. Management:

Some of the species for which the Sopu centre has developed or is currently developing a reliable hatchery technology, would serve as resource enhancement and aquaculture. These include the giant clam, green snail, trochus, sea cucumber (a recent project driven in part by the lifting of a 10-year ban on its harvest and the accelerated harvesting rate that ensued), and even mozuku seaweed, although the need may only be the proper management and harvesting of wild resources of the seaweed. Aquaculture-assisted coastal resource enhancement activities would be enhanced by Section 13 of the Fisheries Management Act 2002, which provides for the declaration of any area of the fisheries waters and corresponding subjacent area to be a "Special Management Area" (SMA). Section 14 of the Act empowers the Minister to designate any local community to be a coastal community for community based fisheries management. At the time of the mission, there were already eight such SMAs.

3.2.3. Technical:

The technical constraints of reliability and quality of seed have largely been resolved. Much of the R&D work of Sopu has established the technical feasibility for the culture of almost all of the species. The remaining hurdle of moving past the pilot stage might be resolved by partnerships with private sector in the establishment and operation of pilot projects and provision of appropriate incentives for investors.

There is a plan to revive the culture of milkfish for the food security needs of island communities that have a brackish resource. As this would essentially be for subsistence and the culture area is a common resource, the need is technical expertise for (a) identifying and assessing the source of wild seed, (b) collecting and handling the fry, (c) nursing the fry, (d) stocking, (e) assessing the primary productivity of the water body for stocking and the natural feed resources for the fish, (f) supplementary feeding if needed, (g) grow-out management, (h) harvesting and probably post harvest processing.

IV. Conclusions

The aquaculture division especially the Sopu hatchery has mostly been successful in establishing the technical feasibility of farming the species that Tonga had targeted for culture. To reiterate, most initiatives have not prospered beyond the research or the pilot stage. The mission finds relevant the observations made in 1998 by G. Preston. In his review of Tongan aquaculture development, Preston (cited in National Fishery Sector Review of Tonga, FAO, 2009) described the reasons for failure of research to contribute to economic development, thus:

"Although basic biological and technical work is an essential beginning to any aquaculture research and development project, economic studies are also needed at an early stage in order to identify and focus resources on the research lines that have a real potential to generate development, and to avoid those most likely to lead into dead ends. Market studies, examinations of comparable projects elsewhere, and financial modelling of alternative production scenarios - should proceed in parallel with technical and biological work rather than following it, as has often been the case in Tonga. Failure to carry out economic feasibility studies at an early stage may be one of the reasons why non-viable research avenues have not been identified and discontinued at an early stage.…"

"Another problem in translating research work into economic development appears to be that even where research may have identified commercial potential there has generally not been a parallel set of extension activities to promote commercial or economic development. At a higher level, there does not appear to be any kind of planning or provision for such extension activities within the aquaculture programmes that have so far taken place. It has been assumed that development will flow on naturally once research has overcome technical problems. In practice, however, the Ministry's aquaculture work has sometimes become locked in the research phase due to the absence of any specific plans or mechanisms for building on research results."

These shortcomings - lack of adequate economic study, weak extension of technology and failure to follow up technology for commercial application - remain relevant. An encouraging note is that the mission finds that the Aquaculture Development Management Plan has recognized these problems and the Aquaculture Commodity Development Plan for 2010-2014 contains specific provisions to address them.

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Annex 1

Persons Met in the Kingdom of Tonga

1. HSH Prince Tu'ipelehake, Minister, Ministry of Agriculture and Food, Forests and Fisheries

2. Sione Vailala Matoto, Head of Fisheries, Fisheries Division MAFF svmatoto@tongafish.gov.to

3. Poasi Fale Ngaluafe, Senior Fisheries Officer, Head of Aquaculture Section poasif@tongafish.gov.to; Fisheries Division (Phone: +676-21399, 27799)

4. Scott McTier, Researcher, James Cook University, on secondment under an ACIAR project

5. Richard Warner, Australian Youth Volunteer

6. Larry Sharron, Manager, Walt Smith Int'l LTD, Aquarium Fish operation, Tongatapu belauaqua@aol.com

7. Manager of a sea cucumber processing operation (from HongKong)

8. Ms Naitilima (Tima) Tupou, Executive Officer, Fisheries Industry Association of Tonga (FIAT) fishexport.tonga@gmail.com

9. George Y.L. Nakao, Executive Chairman, HA'AMO Growers Co. Ltd nakaoco@kalianet.co

10. Ms Tricia Emberson, Secretary, Tonga Chamber of Commerce and Industry, Inc. and Executive Officer, Alatini Fisheries Co. Ltd. tricia@alatini.to

11. Sioeli Pasikala, Head of Asset Management, Ministry of Fisheries sioelipasikala@yahoo.com.au

Annex 2

Feasibility issues of selected species and their farming systems

1. Mozoku seaweed

Enablers/*constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy			*High cost of fuel for refrigeration and high cost of transport*	
Research		Seeding, culture and post harvest technologies are established.		
Extension		A training course has been developed based on the technologies and can be used.		
Institutional collaboration & partnerships		JICA assistance in its culture and harvest as well as promotion and further SPC assistance in its promotion.		
Market development		*Limited product forms developed for diversified markets.*		
Key to success	A systematic feasibility study and implementation of the technical requirements of the species. Future success could rest on product diversification and promotion and market diversification.			
Key Constraint	*Lack of competitiveness in the major market for the seaweed.*			

2. Mullet

Enablers/	Feasibility issues			
	Biological	Technical	Economic	Social
Policy/regulations	Pen culture in lagoon and promotion of the two native species for culture.	Protection of the mangroves fringing the lagoon from deforestation; environmental regulations to maintain the quality of the lagoon.	*Importation of cheaper species.*	*Need to secure the cultured stocks, protection of pens and cages,*
Research			*Need for a low-cost system of culture.*	*Need to explore a community-based or cluster-based model of farming.*
Extension				
Institutional collaboration & partnerships				
Market development				Mullet is a preferred species; native species command a good price in the local market.
Key to success	Lower cost production; continued protection of the lagoon's quality.			
Key constraint	*Security of stock*			

Country 7

Samoa
30 August - 02 September

I. Introduction

Aquaculture in Samoa is small even in comparison with other Pacific Island countries and territories. While past research, pilot project and attempts at commercial farming have included at least 10 species (tilapia, mullet, milkfish, *Eucheuma* seaweed, green mussel, giant clam, edible oysters, pearl oysters, molly, trochus) only tilapia remains as an aquaculture species. There is seed production and reseeding of giant clams. Samoa has a fairly abundant freshwater resource from its river systems but with limited area for freshwater culture. Tilapia is being used in some integrated systems (with duck, chicken, pig and root crops and vegetables) or in small backyard ponds. It is mainly for subsistence i.e. for consumption of the extended family or even the clan. A freshwater hatchery dedicated to tilapia is operational while the marine hatchery is not functioning. Australian yabby was introduced and farmed in a very limited scale but did not prosper for internal management reasons. Of the several marine species that have been tried, trochus was found to have established in some reef areas whereas giant clam continues to be seeded in marine protected areas, the latest batch of 1000 seed coming from the hatchery in Sopu, Tonga provided in 2010.

Natural hazards that included two hurricanes and recently a tsunami have contributed to the lack of progress in the marine aquaculture initiatives, wiping out mussel and seaweed trials and stocked giant clams.

The traditional land ownership system is seen as an impediment to investments by people from outside the community. It may be pointed out that apart from a giant clam venture for aquarium trade, and no pilot project has shown results that would attract investors. The commercial production and trading venture on giant clam has ceased operating because "the entrepreneur has found regular employment".

The traditional political structure in villages, where the decision making and clan welfare resides with the chief of the clan (matai), can be a positive factor in introducing and sustaining aquaculture activities within a community. Tilapia farming for subsistence (of the clan, not just of a family) can be sustained mainly because the matai, is responsible to assure the clans food supply. On the other hand, initiating changes can be a challenge when decision making rests solely on the traditional chief.

Legislation that would enable longer term leases on land owned by the community is being drafted. The traditional power structure will remain a given in extension work; the gatekeeper for innovations and technology for the community is the matai who has to be convinced or better yet, whose support has to be won, to introduce an innovation into the community.

II. Background information

This section is based on the response to the questionnaire provided by Joyce Samuelu Ah Leong, (Principal Inshore Fisheries Officer, Fisheries Division, Ministry of Agriculture and Fisheries) and the briefing given to the mission by the aquaculture section.

The Fisheries Management Bill 2010 includes provisions that call for an aquaculture management and development plan to improve research and development in aquaculture. The annual activities of the Aquaculture Section are derived from the Fisheries Division Annual Plan which in turn is based on the Ministry's Corporate Plan 2008-2012.

The main research area for aquaculture has been the introduction of new marine and freshwater species supported by growth performance and feed studies. Before 1991, a number of species were introduced that included freshwater prawn (*Macrobrachium rosenbergii)* the green mussel *(Perna viridis)*, tiger shrimp *(Penaeus monodon)* and the cla*ms (Tridacna derasa, T.gigas)*. Seaweed culture and baitfish culture (molly species) were also carried out including polyculture of moly with freshwater prawn (FAO SAP, 2001).

Tilapia *Oreochromis mossambicus* was introduced in the early 1950's; it did not gain acceptance as a food fish. In 1991, *O. niloticus* was introduced for farming. Other introductions, mainly for stocking and attempt at removing the *O. mossambicus*,were carried out in 1994, 1996, 1997 and most recently in 2009 with the GIFT tilapia. The seaweed *Euchema* was first introduced in 1975 for culture trials but details of this introduction are not documented. It was again introduced in 1991 to examine the possibility of 'low technology, low investment' farming and as an alternative cash crop for communities. The trials ended in 1992 due to severe grazing and cyclones. The Pacific oyster (*Crassostrea gigas)* was introduced in 1990 for culture. It was discontinued after two years of trial because of high mortality from predation, poor management and maintenance. Poaching was also a problem. The Safata Bay was identified as a potential site for oyster farming. However, no commercial culture has been established. Other introductions of new species for commercial farming included the red claw crayfish *(Cherax quadricarinatus)* from Australia in the mid 90's. However company management problems contributed to the failure of the enterprise.

Some marine species for resource enhancement were provided to communities for stocking their fish reserves. The community's primary involvement protected the seeded stocks.

Training of farmers that have giant clam nurseries and tilapia farms is conducted by the Fisheries Division. Training teaches proper maintenance of the clam nurseries and fish ponds, feeding, and monitoring of fish in ponds. Annual consultations are held to exchange experiences and discuss the results of monitoring tilapia farms and clam nurseries so that management practices can be improved. Staff of the aquaculture service have undertaken various technical training programmes overseas. (For example, the aquaculture officer who was the mission's technical guide has recently attended the Integrated Fish Farming course in the Freshwater Fishers Research Centre in Wuxi, China).

III. Materials and Methods

The sources of information for the assessment included the following:

1. A questionnaire sent to the focal institution by FAO SAP to provide leads and indicators for the mission to follow up;
2. Regional and national reports and assessments relevant to fisheries and aquaculture of Fiji
3. Face to face interviews with key informants; these included farmers, management, technical and extension personnel in government. The list of persons met is in Annex 1.
4. Visit to projects, farms (integrated farms, women in business projects, and school ponds) and hatcheries.
5. The 1984 review of aquaculture in the Pacific Island region by the Pacific Islands Development Program, East West Center, Hawaii.

IV. Findings

This mission report provides indicative and broad findings. The findings are categorized into the following:

1. Sector management (policy and regulations, strategy and plans)

1. **Policy**. **The Statement of Development Strategy 2008 – 2012** calls for the agriculture sector, in particular village and subsistence fisheries, to strengthen supply of fisheries resources and promote stock enhancement. The Strategy proposes to sustain the delivery of public sector support services for fisheries development including nursery development for aquaculture.
   MAF Corporate Plan 2008 – 2013. The two long term goals under this plan are aligned with the main goals set out for aquaculture, namely, (i) Improved local food and nutritional security by assuring a sufficient supply of traditional healthy food products, and (ii) Improved commercial development and biosecurity to promote trade.

   Fisheries Division Mission. The mission statement, expressed in the corporate plan, is to develop fishery resources by promoting optimum and ecologically sustainable use of the country's fishery resources and developing suitable alternatives to substitute for harvesting depleted resources.

2. **Regulation and assistance to private sector**. The Fisheries Amendment Act 1999 has a provision to regulate aquaculture operations. The Fisheries service is mandated to regulate any aquaculture development through the issuing of licenses and terms and conditions for any operations. The Fisheries service has been assisting local operators through technical and management assistance. In 1993 and 1995 it assisted in the import of the red claw crayfish for commercial culture which closed three years later. In 1994, Fisheries assisted in the importation of live clams for the private clam nursery at Namu'a Island. These clams were for restocking and resource enhancement. The plan to grow the clams for the aquarium trade was not pursued.

3. **Resource management**. Aquaculture, mainly though seed production, is used for resource enhancement. For instance, *Trochus niloticus* was introduced in the early 1990's for seeding the reefs. It offered an alternative source of food and with the shell as a high value material for export. In 2003 and 2005 a re-introduction was carried out in four villages. The trochus were spawned in the Fisheries hatchery in early 2004. The seeds were distributed to the villages' fish reserves for establishment. Giant clam species *Tridacna derasa* was first introduced in 1988, followed by the introduction of *T.gigas* and the *Hippopus hippopus*. These two species were believed to have been all fished out and thus re-introduced into Samoa's reefs in 1988; other reintroductions of these species followed in 1991 to 1996, for the fish reserves.

2. Aquaculture initiatives and impacts

The species (and systems) that have been initiated in Samoa, and a brief description of their results are described in the table below.

1. *Tilapia* is the only aquaculture species that has remained, to be promoted and adopted, in small farms, school ponds, and women-in-business projects integrated with pigs and/or poultry and root crops and vegetables. The constraints include the predominance of the *mossambicus* species in river systems and the lagoon, genetic deterioration of broodstock, and the small scale of current farming, to warrant any commercial investment in feed production. There is also need to further improve pond management skills of farmers.

2. *Giant clam* restocking to re-establish population has had mixed results; stocking the clams in marine protected areas seems to be working; a request by a community to set up a small-scale hatchery for them to operate indicates the importance of supporting community-based giant clam seed production and reseeding. The giant clams are among the very few species that were successfully spawned and reared from the hatchery facility in Samoa. In 2001 the marine hatchery was established and *T.derasa* and the *T.gigas* were successfully spawned and reared. Trochus was also successfully spawned and reared in 2005, and juveniles were released to suitable reefs. The hatchery was closed down in late 2005 due to property ownership issues.

3.	*Trochus*. The seeding of hatchery-reared trochus has resulted in the establishment of trochus beds in a number of locations in the reef. This suggests a successful initial effort.
4.	*Green mussel*. Good growth from a trial that was destroyed by hurricane. Spats were introduced from Tahiti. The system was rope culture and raft culture, with the latter found to be more suitable. There was also a poaching problem and biofouling, predation by crab and puffer fish, and then the siltation of the site after two cyclones. Earlier trials produced mussels that were marketed and had good demand.
5.	*Freshwater prawn*. A hatchery technique was developed with successful results and seed were provided to a farm, which was able to harvest market size (51 to 90 g) prawn. Prawn feed from local ingredients was also developed although a good binder could not be found. The farm eventually closed down from poor management; prospective farmers who were looking at it as a model changed their plans.
6.	*Marine shrimp*. There was a good market for shrimp (imported) and a promising trial of *P. monodon* from Tahiti, stocked at low density, with no supplementary feeding, and cultured with mollies in ponds. Land for culture was limited and further trials were abandoned.
7.	*Crayfish*. A commercial venture of introduced crayfish was discontinued after a management problem within the company.

3. Lessons

The analysis for the important and potential species appears as Annex 2, with tilapia (*O. niloticus*) as the sole illustrative example. The other species such giant clam and trochus are well illustrated in other country reports. Trochus was seeded and recent monitoring showed some survival in the reefs but with no indication of commercial populations. Green mussel which was introduced, with indications of a good local market but following the pilot project's destruction by cyclone, government interest was not renewed and there was no private sector interest in mussel farming.

3.1 General lessons

Many of the introduced and local species that were tried for culture had initial success and some even exhibited commercial feasibility. All except tilapia did not continue, mainly for two constraints: management skills were inadequate and, other than mussel and freshwater prawn, there was no indication of a local market with an attractive price. Economic feasibility was not established for any of the species and systems that had been tried.

3.2 Specific lessons

This section consists of lessons from the strategic, management and technical issues.

3.2.1 Strategic:

- An aquaculture act which has been submitted to parliament for enactment would likely improve the opportunities for private investments, although there has not been any commercial scale operation other than the aquarium trade of giant clam and crayfish farming, which did not prosper.

- A species like tilapia could become the foundation for an integrated fish farming programme aimed at improving food security. It was in fact decided to be the major culture species for food security because it was seen as an easy fish to culture in the fairly abundant freshwater resources of Samoa (FAO Sap 2001), hence its introduction and promotion for culture. At present, the owner of a small tilapia farm integrated with chicken has stimulated a wider interest in fish farming by having his farm publicized on Samoan television. One immediate result is the interest expressed by a church group. Samoa has many denominations that would have the means to invest in commercial scale tilapia farming or can encourage and provide start up capital for small scale operations among their members.

- One implication of the above is that the aquaculture sector could use a "champion" to promote fish farming, such as this farmer, who is in fact a businessman-politician and a matai.

3.2.2 Management:

- Integration of tilapia with crop and pig/poultry would improve extended family productivity and food security. It need not complicate management of the farm as most farmers are already raising poultry, root crops and vegetables. A practical action is to help the existing farms become successful - without providing too much subsidy - to serve as models for a widespread promotion of the integrated farming system for community food supply.
- A community-management approach for giant clam appears to work; one community has requested assistance in the establishment and operation of a giant clam hatchery so they can produce clams for seeding the reefs and for the aquarium trade. They will clearly need technical assistance, which the government could provide from its own experts or provided through a technical cooperation project with, say, Tonga. This argues for the empowerment of communities through training in entrepreneurship, management and technical skills not only in giant clam but in other species and farming systems. This also indicates that communities could eventually take over the production of fish seed for their use and for sale.

3.2.3 Technical

- The major technical constraints to Samoan aquaculture development have been the lack of seed production facilities, lack of sites for large-scale aquaculture, and lack of compounded feeds and suitable feed ingredients. These were largely resolved by the establishment of a freshwater hatchery in Apia. (The marine species hatchery was established in 2001 but is now dysfunctional). A pellet machine was purchased in late 2004 for feed formulation, but feed remains costly because some ingredients have to be imported.
- There is need to improve tilapia seed production and quality of seed. As of now the aquaculture service also produces feed for distribution to tilapia farmers. It will remain this way until there is a wider demand for feed that would warrant its production on a commercial scale by the private sector. However, as some local ingredients are available, a farm-made feed formulation could meanwhile be developed and promoted to the tilapia growers. The women in business groups could be trained in the formulation of farm made feed, which they could use for their own farms and sell to other farmers.
- Apart from the development of feed and production of seed, the aquaculture service could also focus R&D attention to improving the efficiency of the land-based integrated farming system (fish/crop/livestock). It could develop and demonstrate various types of integration suitable to specific areas in the two main islands. This would improve the overall food production opportunities of communities.

IV. Conclusions

The relatively large size (nine technical staff) of the aquaculture section of the fisheries division compared to its current operations and the extent of aquaculture indicates the importance placed by government on aquaculture and its expectations of its future role in the economy. There is however very limited aquaculture production and few cultured species. In fact, it is only tilapia that is being farmed and by only 23 active farmers. The farming system for the species - which is the integration of livestock, crops and fish - nonetheless can be an option for producing more food in a limited land area. The women-in-business projects give indication that integrated fish farming can be promoted as a group enterprise. This can be an appropriate model for a system that is operated by a clan. As there has recently been interest by some religious denomination, it could also be a model that the religious denominations in Samoa can promote for their members.

Meanwhile, past evidences of their market potential make it worthwhile for the aquaculture service to again try the culture of green mussel and conduct trials on small commercial models of freshwater prawn, preferably also in an integrated fish-poultry-crop system to produce staples and a cash crop.

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Annex 1

Persons Met in Samoa

1. Ms Olofa Toaupepe, Acting Chief Executive Officer, Fisheries
2. Ms Joyce Samuelu Ah Leong, Principal Officer, Aquaculture Section joyce.samuelu@fisheries.gov.ws
3. Clifton Sae, Senior Officer, Aquaculture Section clifton.sae@fisheries.gov.ws
4. Seuamuli "Steve" Tolive, Senior Fisheries Officer, Advisory, Savaii Center
5. Tauvae Sua, Fisheries Officer, Aquaculture Section
6. Isaia Matau, Fisheries Officer, Aquaculture Section
7. Ms Maria Sapatu, Senior Fisheries Officer, Inshore Fisheries Section
8. Ms Sala Vaimili, Tilapia fishpond/chicken, Vailele Village
9. Caretaker, Women in Business Project (tilapia/chicken), Falelauniu Village
10. Mataia Iose (chief and owner), Swimming turtle and tilapia pond, Satoalepai Lake, Savaii
11. Women project participants, aquaponics project (tilapia/vegetables), Savaii
12. Vili Fuavao, FAO Sub-regional Representative for the Pacific Islands, FAO Subregional Office for the Pacific Islands (SAP) vili.fuavao@fao.org
13. Masanami Izumi, Fisheries Officer, FAO SAP masanami.izumi@fao.org

Annex 2

Feasibility issues of the illustrative aquaculture species, Tilapia

1. Tilapia (*O. niloticus*)

Enablers/ *constraints*	Feasibility issues			
	Biological	Technical	Economic	Social
Policy	Government introduced tilapia for freshwater fish culture and the first introduction was *Oreochromis. mosssambicus*, followed by *O. niloticus* .	Government freshwater aquaculture hatchery is dedicated now to tilapia seed production.		
Research	Introduction of improved strains has provided better quality seed.	*All-male tilapia seed production is needed. There is also need to improve the efficiency of the integrated system now being practiced.* *No formulation of a farm made feed is available; feed is provided free by government.*		
Extension		The aquaculture section annually organizes a meeting among farmers for exchange of experience, has a group of well-trained staff for freshwater aquaculture research and extension, and there are externally funded projects promoting integration of aquaculture in rural livelihoods.	*Demonstration and pilot projects do not include assessment of their economic benefits.*	*The interest shown on tilapia farming by one of the religious denominations highlights the need to expand extension and technical assistance to a wider range of stakeholders.*
Institutional collaboration & partnerships		*Improving the technical efficiency of integrated system would need R and D cooperation with USP's agriculture college in Apia, which is as yet lacking.*		
Market development		aste test was conducted as part of the introduction, which showed it was acceptable.		Tilapia is accepted by population.
Keys to success	A sustained R and D on tilapia and technological back up to farmers from the government research station. Demonstration of the economic benefits of integrated small scale farming system.			
Key Constraints	*Lack of quality feed, low level of pond management skills, mixed sex stocks in ponds and a lack of all-male production technique*			

Country 8

Cook Islands
TCP/CKI/3201
FAO Aquaculture Development in Cook Islands
5-24 July 2009

I. Introduction

The mission was carried out under the TCP/CKI/3201: Cook Islands Aquaculture Development. The work of the consultant was under the direct supervision and guidance of Mr Koroa Raumea, Director of Inshore Fisheries and Aquaculture Development of the Ministry of Marine Resources and Mr Masanami Izumi, Fishery Officer, FAO SAP. Work was mostly carried out at the MMR Headquarters in Avarua. The mission arrived on 4 July, began work on the 6th and returned home on the evening of 24 July.

1. Background and purposes of the mission

The project was requested of FAO SAP by the Government of Cook Islands. It is in two parts and planned to comprise three missions, the mobilization of the second (and the third) being dependent on the findings of this first mission. It carried out a broad assessment of the feasibility of further aquaculture development activities based essentially on the lessons and impacts of previous aquaculture development initiatives in Cook Islands and the conditions and future needs for aquaculture development. The specific purposes were to:

1. Review the past and current national fisheries policy, management, development and strategic plan, in particular sustainable aquaculture development in Cook Islands (CI);
2. Assess the impact of aquaculture development to date, including technical, economic, social, environmental and institutional aspects;
3. Recommend how planned aquaculture development, activities and projects should be designed to further improve its effectiveness, development impact and sustainability;
4. Recommend appropriate technology packages and preliminary outline designs for pilot-scale tilapia and freshwater prawn farming[4]; and
5. Assess whether current level of funding allocated for aquaculture development is sufficient to further improve sustainable aquaculture development in CI.

2. Sources of information

A sizable body of secondary information in the form of project reports, reviews, and plans provided much of the materials. The primary information came from discussions with the Secretary of the Ministry of Marine Resources (MMR) and the Director of Inshore Fisheries and Aquaculture Development (InFAD), a visit to a private aquaculture facility on Raratonga operated by the head of a local growers (of agricultural crop) association, the Titikaveka Growers Association) and a lengthy discussion with him and an associate, discussions with a technical staff of InFAD, and meetings with the former mayor of the Island of Atiu, a Manihiki Island resident. He was also Chief of Staff of the Prime Minister's Office and now an entrepreneur in the tourism industry, a member of the Titikaveka Growers Association, a resident interested in oyster culture, and the Director of the Northern Cook Islands Fishing Company. The salient information from these meetings is incorporated in the analysis.

In addition, technical information and expert views were obtained through email correspondence from two aquaculture specialists: a former research and technology verification specialist of the Philippine-based Aquaculture Department of the Southeast Asian Fisheries Development Centre (SEAFDEC AQD) who was working with a commercial aquaculture company in Palau, and an aquaculture scientist and now agribusiness consultant who had been head of the Technology Verification Division of SEAFDEC AQD.

[4]Revised during the mission to include milkfish culture.

The list of persons met appears as Annex 1.

The report was discussed at a stakeholders meeting organized by the MMR on 24 July. The meeting provided more information, which was incorporated in this report.

II. Policy, Strategy, Plans and Capacities for Aquaculture Development

1. Overview of the fisheries sector

This brief overview of the fisheries and aquaculture status of the country provides a context to its aquaculture development plans and activities. The main development in fisheries has been the expansion of pearl farming on Manihiki and its establishment on Penrhyn and Rakahanga. The Marine Resources Act has been subject to periodic updating and development and the latest version is the 2005 Act. There has been a move towards rights-based fisheries management and localization of the longline fishery; and an increasing use of "*raui*" - fishing bans over areas of lagoon and reef - to improve habitat and conserve fish stocks. Some of the main features of the development of the sector are as follows:

a. Offshore fishing. The government has been keen to promote long-lining and local or joint venture investment in the sector. Foreign fishing is now limited. Cook Islands is a party to the multilateral treaty which permits access by US tuna purse seiners, although US vessels rarely fish in Cook Island waters (excerpt of assessment report conducted for ADB by Jonathan Cook (2006).

b. Reef and lagoon fishing. Most reef and lagoon fishing on the outer islands continues to be undertaken by part-time fishers or for subsistence. The main fishing activities are trolling for pelagic species around the Rarotonga fish aggregating devices (FADS), netting flying fish and hand-lining for reef fish. Some day and night spearing of fish and lobsters is also undertaken. Full and part-time fishing efforts have increased steadily. FADs were designed to help local fishermen catch fish in greater quantities, more safely and easily. FADs are typically placed about one kilometre or more offshore where the depth of the ocean is between 800 to 1600 meters. On islands where the majority of fishing vessels are canoes, FADs can be placed closer to the shore. According to SPC, the further away from shore the FAD is SET, the more effective it is at aggregating fish. A first FAD in the Cook Islands was deployed in the early 1980s. Since then, over 60 have been constructed and placed around Rarotonga, Aitutaki, Mangaia, Atiu, Mauke, Mitiaro, Palmerston, Manihiki and Penrhyn. On average, FADs remain afloat for 18 months, although this is improving. Each FAD costs about NZD5,000 to 7,000 for construction and deployment. Fisher organizations help with the costs and donate money to help maintain the FADs. Since the establishment of FADs in the Cook Islands, there has been a large increase in the local catch of pelagic fish. (http://www.spc.int/Coastfish/Countries/CookIslands/MMR2/FADs.htm accessed 29 July 2009).

c. Aquarium fish production. There are 35 species of aquarium fish being collected by divers but only five species are in regular demand. The majority of aquarium fish are caught on the reef slope in depths ranging from 8 to 35 meters, with occasional specimens taken at depths in excess of 50 meters. One company (CI Aquarium Fish Ltd) is licensed to catch and export aquarium fish. It operates only on Rarotonga and exports around 20,000 fish valued at $200,000 per year. Potential exists to commence aquarium fish on a number of outer islands in due course, but this is subject to reliable and regular direct air connection to Rarotonga.

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d. Game fishing. Commercial game fishing charter boats operate in Rarotonga and Aitutaki. Game fishing activity is trolling for tuna, billfish, wahoo and dolphin fish. Some commercial fishers also take tourists out fishing.

e. Pearl oyster farming. Black pearl production increased rapidly, from 1994 to 2000 Pearl but production on Manihiki was set back significantly by Cyclone Martin in November 1997,. The cyclone destroyed most infrastructure and claimed several lives. While it was able to recover rapidly, a further setback was experienced (in November 2000 when a moderately severe outbreak of vibriosis occurred in the Manihiki lagoon.

The pearl industry was poised to expand to Penrhyn but the economic downturn, high costs of production and low world prices of pearl have set back the industry. However, the raw records from the Secretariat of the Pacific Community (SPC) on pearl production from 2005 to 2008 show a stable production.

Product	Year	No of Pieces	Total Value in NZD
Pearl	2005	126,846	2,314,942
Pearl – Mabe		12,685	63,423
Pearl	2006	157,231	2,869,462
Pearl – Mabe		15,723	78,615
Pearl	2007	163,769	2,988,788
Pearl – Mabe		16,377	81,885
Pearl	2008	157,923	2,882,096
Pearl – Mabe		15,792	78,962

f. Trochus shell production remains the major form of aquaculture (or managed production) apart from pearl oysters. Trochus was introduced to Aitutaki in the 1950s and recently to other islands. Commercial harvests were limited to Aitutaki and Rarotonga (with production of about 25 tons in 2000) but stocks on Palmerston, Manihiki and Penrhyn subsequently contributed to the shell harvests. A first harvest in Palmerston in 1997 yielded 1.5 tons of shell, and harvesting occurred on the other islands after a few years. Aitutaki's trochus fishery is well-managed and provides a significant income for many island families. However, as tourism expanded, Aitutaki residents became less interested in collecting and processing trochus. Where trochus are abundant, the harvested meat is a substitute for the meat of native shellfish used in traditional dishes, helping to alleviate fishing pressure on native shellfish (excerpt from ADB assessment report op. cit.).

g. Giant clams were harvested until the resources began to decline from over-harvesting. Besides stock management, MMR began rearing the native clams in the Marine research centre in Aitutaki and transferred them on to reefs in the lagoons. SPC raw data show that harvest of giant clams declined suddenly after 2005 from 6400 pieces valued at NZD32,000 in that year to 320 valued at NZD1,600 in 2006, recovering slightly to around 1860 pieces (NZD6,300) in 2007 and then dipping to only 1060 pieces (NZD5,300) in 2008.

h. Seaweed (*Eucheuma sp.*) was introduced to Aitutaki in the late 1980s. However, the lines were destroyed by a cyclone and the project was not continued. A second project to introduce seaweed farming to Penrhyn, Rakahanga, and Pukapuka atolls, building on the experience gained in Kiribati, did not meet its goals due to a number of natural, biological and social risk impacts (Luxton and Associates 2001). The risk impacts are described in Annex 8, "Lessons from previous initiatives".

i. The culture of finfish species including milkfish and tilapia and of freshwater prawn has been tested in farm trials. The development did not go beyond the trial stage however. There is a report of a 1-ton production of tilapia in 2007 valued at NZD8,400 in the SPC database for Cook Islands from Titikaveka, Rarotonga, which would have referred to the harvest from the on-farm trial. There is also ongoing capture of now wild mossambicus species (*O. mossambicus*) in natural water bodies such as the Teroto Lake in Atiu (a resident has reported catching, depurating and smoking the fish for local sales during the Stakeholders Workshop held on 24 July to discuss this report (see Annex 11). No baitfish culture has been established but culture trials of milkfish for food and bait have been carried out in Mitiaro and recently (for food) in Raratonga.

2. Policy

Under the Corporate Plan of the MMR, the Ministry's overarching social development policy is to establish effective partnership with communities, businesses and other agencies so that throughout the nation people receive maximum long-term benefits from sustainable development and utilization of marine resources. MMR Act 2005 mandates the Ministry to rapidly expand development in areas offering the greatest potential for export, import substitution, or both. The MMR's purpose for aquaculture is to "Encourage the sustainable development of potential aquaculture species in the Cook Islands".

3. Legal framework for aquaculture development

The regulatory basis for governance of aquaculture development rests largely with the provisions of the Fisheries Act. The specific provisions for aquaculture are contained in Part I: Fisheries Conservation, Development and Management. The two guiding principles for its development and management are ecological sustainability and social, cultural and equity. To implement these principles, the Act specifies these measures:

Ecological sustainability:

(i) assessment of the impacts of aquaculture on aquatic ecosystems and other uses of aquatic resources;

(ii) Minimizing pollution from aquaculture.

Social, cultural and equity:

(i) maintaining traditional forms of sustainable fisheries management;

(ii) protection of the interests of artisan fishers, subsistence fishers and island communities and ensuring their participation in the management of fisheries and aquaculture; and

(iii) Broad participation by Cook Islanders in activities related to the sustainable use of marine resources.

Governance of an economic sector is normally executed by a mix of measures including command and control or mandatory (enforcement of regulations), market-based (i.e. certification, eco-labels, etc), voluntary management (adoption of best practices and self-imposed standards reinforced by organizing into farmers associations), and stakeholder participation (by which government is only one of the stakeholders and decisions are made through stakeholders' negotiations). The provision of the Act is explicit on regulations but also encourages the other options. In fact the social, cultural and equity measures explicitly encourage a participatory management regime.

There are no specifically designated aquaculture zones but the environment provisions of the Act apply to the location of aquaculture facilities and farms. They describe the kind of areas where aquaculture facilities and farms may or may not be sited. The specific provisions for locating and operating aquaculture facilities and farms are in the section, "Aquaculture Management Areas". The provisions include the designation of an aquaculture management area based on scientific, social, economic, environmental and other considerations.

The MMR Secretary or a local authority prepares the aquaculture management plan for the area. The plan identifies the area, describes the status of aquaculture activities in the area; specifies management measures to ensure sustainable aquaculture; specifies the process for allocating and authorizing participation in aquaculture activity in the area; and makes other provisions to ensure sustainable aquaculture. The MMR Secretary approves an aquaculture management plan prepared by a local authority subject to its observance of the above provisions.

This regulation serves the broad purpose of ensuring that aquaculture is managed responsibly. It also has the very important purpose of assuring investors that their investments are protected. The aquaculture management area is a rough equivalent of the aquaculture development zones and aquaculture parks in some countries. The difference is that an area development plan is carried out on a designated aquaculture area (as in Iran), or incentives such as tax breaks or tax holidays are offered to the investors who set up aquaculture enterprises in aquaculture investment zones (as in Malaysia), or technical assistance is facilitated for users of mariculture parks (as in the Philippines).

4. Strategic planning for inshore fishery and aquaculture

MMR's strategic plan envisions two outcomes for commercial inshore fishery and aquaculture development (IFAD): (i) Improving income generating opportunities for the private sector based on the sustainable use of marine resources, particularly in the Outer Islands; and (ii) Ensuring sustainable fishing and conservation practices for long term food security. These are Outcomes 3 and 4 in the Ministry's Corporate Plan for 2009-12. To achieve them, the plan methodically set a strategic framework comprising six linked and mutually supportive strategies each with a performance indicator (mostly expressed as outputs) and clear focus of responsibilities for their execution.

5. Development planning based on species potential for culture

The development plan for aquaculture is anchored on a practical scheme for assessing aquaculture opportunities. In line with the three pillars of sustainable development, economic, social and environmental objectives, a set of criteria was specified as a basis for assessing the potential impacts and benefits of farming a species. The system is explained below.

The screening system for candidate species targeted at the tourist market is illustrated by the process that was followed**:**

- First, the candidate species were listed;
- Second, the filtering criteria as set, are as follows:
  - Competitive advantage
  - Market
  - Scientific needs and support available
  - Economics
  - Skills, training needs and support available
  - Risks
  - Other issues (legislation, social and cultural)
- Third, the essential attributes of each criterion are identified and each attribute assigned a weight;
- Fourth, a technical panel is constituted and, using the best available information, the members score each candidate species based on the attributes of each filtering criterion;
- Fifth, a summary of the scores is presented in tabular and graphical formats to show the relative potentials of each species.

The scores are translated into a qualitative description indicating what species have the most potential and why, as shown in Table 1.

Table 1. Commodity scores

Commodity	Commodity Criteria 1: POTENTIAL IMPACT (potential of commodity to make a positive impact)	Commodity Criteria 2 POTENTIAL FOR SUCCESS AND BENEFIT (feasibility of successfully developing the commodity)
Abalone (tropical)	Low	Medium
Carp	Low	Low
Coral	Medium	Medium
Freshwater prawn (Macrobrachium)	**Medium**	**Medium**
Giant clam (Tridacnae)	High	Medium
Kappaphycus seaweed	Low	Low
Marine fin-fish (food)	Low	Medium
Marine shrimp (Penaeid)	Medium	Low
Milkfish	**Medium**	**Medium**
Mud crab	Low	Low
Ornamental fish	Medium	Medium
Pearl oyster	High	Medium
Rock lobster	Medium	Low
Sea cucumber	Low	Low
Sponge	Low	Low
Tilapia	**Low**	**Medium**
Pearl oyster meat	High	Medium
Trochus	High	Medium

Further improving its utility, the assessment model describes the constraints to developing the farming of the species (for instance, "lack of trained manpower") and the considerations and desired actions to overcome the constraint (such as "local training by an expert from a named center of excellence and participation of local officers, technicians and farmers on study tours and seminars in other countries").

The outcome of the system has been the basis for the plan to develop the species with good potentials. The concept and methodology for the model is described and illustrated in the report "Potential of Aquaculture in the Cook Islands" (InFAD, 2006).

6. Capacities for aquaculture R&D

The current InFAD staff consists of fourteen (14) technical officers. Eight are based in Rarotonga and provide management and technical support for field projects; three (3) are posted in Aitutaki and the three (3) others are operating in the outer islands. Pearl culture is now a separate division so that InFAD is now focused on the other commodities such as giant clams, trochus, corals, seaweed, crustaceans, and finfish.

The InFAD staff performs technical servicing to clients and provides the technical inputs to concerned divisions in environmental monitoring, food safety monitoring (i.e. ciguatera alerts and mitigation advice), compliance with regulations that are relevant to aquaculture and inshore fisheries, and organizing and supervising community-based fisheries projects.

Laboratory analysis is focused on water quality because of the need for a strong environmental monitoring and surveillance especially of the lagoons. This could be provided for aquaculture purposes to include limnology and soil analysis. There is no facility for feed or nutrition analysis that could be applied for research and advice on feed formulation.

Research and development on giant clams (*Tridacna* and *Hippopus* sp.) have covered the range of studies and technology from breeding, spawning, hatchery, nursery and culture as well as post harvest and marketing. Two marine research centres, Tongareva on Penrhyn Island and Araura on Aitutaki, have been developed for research and development on these species and commodities (as well as for pearl oyster). Tongareva on Penrhyn is planned for rehabilitation. Research activities in finfish and crustaceans have been limited to on-farm or on-site testing of growth performance of introduced species (such as *Macrobrachium rosenbergii* and GIFT tilapia (*Oreochromis niloticus*), indigenous species introduced from other islands to areas where they are not growing naturally, such as Kappaphycus seaweed, or not their natural range or habitat such as milkfish (Country Report 2006). The results and lessons from these R&D activities are discussed in the next section.

The funding for research has also been limited to supporting these trials and very little is allocated for strategic studies. As a cost-effective alternative, the technology needed has largely been acquired from other institutions and centres elsewhere in the region through information and training.

There are no specific aquaculture training centres in the country. The technical aquaculture and aquaculture-related expertise of the current staff of the Inshore Fisheries and Aquaculture Division have been acquired from formal courses and special training and study programmes. These included practical courses and seminars in institutions and centres located in other countries of the region and elsewhere.

Other areas of expertise that would support aquaculture research and development in which MMR has demonstrated a good capacity are in information gathering, analysis, development and dissemination, and project development.

Attempts to develop demonstration models for farmed species have been constrained by the inability to establish the economic viability of the species. Nonetheless, the field trials in milkfish, tilapia and freshwater prawn have been conducted in collaboration with the private sector; the harvests from these trials were marketed. The elements and information for a value chain analysis are available from the

aquaculture species selection mechanism referred to earlier. A value chain analysis would be useful even if the cultured fish marketing system for the local market and the tourist industry is not expected to require a highly complex logistics and management support. Handling, transport, value addition, and information on demand (as well as desired product forms) and for pricing could be developed with the private sector, the communities, and the prospective institutional buyers catering for the tourist industry.

A credit scheme for capitalization of individual or community enterprises is not among the portfolios of the banks operating in Cook Islands. A plan to provide small grants to individuals residing in the Outer Islands to help them start a small enterprise is being developed.

Collaborative assistance in either funding or technical assistance for fisheries R&D and capacity building have been provided by a number of agencies that include the NZAID, ACIAR, ADB, AUSAID, CIDA, EU, FAO, FFA, ICOD, JICA, SPC, UNDP, UNCDF, and USAID. Projects have concentrated on provision of shore-based plant and equipment (such as buildings, ice plants, and aquaculture and mariculture research and training centres and fisheries stations), fishing vessel construction, fisheries harbours, fish aggregation devices (FADs), research, training, and marketing. Much of the assistance has been directed towards the pearl culture industry.

III. Lessons from previous projects and initiatives

The strategic, management and technical lessons from previous initiatives were culled out from the reports on the projects and discussion with the Director of Inshore Fisheries and Aquaculture for the purpose of (i) informing potential projects of the positive lessons, (ii) alerting the projects of possible pitfalls, and (iii) building on the positive aspects of these previous projects. In summary, the various lessons that are identified in Annex 2 emphasize the following requirements for a successful project:

1. Essential requisites

These are the prior requirements or conditions without which a project can not succeed:

1) Risk assessment – identification of the potential risks, and the management response to each risk.
2) Establishment of the requirements for the farming system's (species and its production system) biological feasibility, technical feasibility and economic viability. This includes the social, cultural and environmental compatibility of the project which should be built into the planning of the project.

2. Enablers

The enablers facilitate the implementation of a project. These comprise the management and technical support services to the project and subsequently to an up-scaled operation. From the lessons yielded by the previous projects, these would include the following:

- Technically capable field staff and cooperator
- An on-farm trial plan understood and agreed to by all parties
- An efficient logistics support
- Effective project communications protocols
- Sufficient resources to support implementation
- Better Management Practices developed for the farming system usually anchored on a Code of Conduct for the industry, the parent of which is FAO's 1995 Code of Conduct for Responsible Fisheries.
- The lessons from the previous projects in milkfish, tilapia, freshwater prawn and seaweed, and from pearl oyster farming, are categorized into Strategic, Management and Technical lessons.

IV. The prospects for aquaculture development projects

This section identifies the technical options for specific aquaculture pilot projects and discusses a strategic recommendation for aquaculture development. These are informed by an analysis of the indications of biological and technical feasibilities and economic viability of nine (9) production systems of five (5) species. These nine systems were identified from meetings with key informants.

A. Indications of feasibilities

The species and systems, as well as their potential sites, are (1) pond culture of milkfish in Rarotonga, (2) stocking and grow out of milkfish in a brackishwater lake in Atiu, (3) stocking and grow out of milkfish in brackishwater pools around Penrhyn, (4) hatchery and tank culture of *O. niloticus* in Rarotonga, (5) pond or tank culture of *O niloticus* in Atiu, (6) pond or tank culture of *M. rosenbergii* in Atiu, (7) polyculture of *M. rosenbergii* and tilapia in Atiu, (8) tank culture of silver rabbitfish *Siganid argenteus* in Rarotonga, and (9) Pacific oyster *Crassostoea gigas* culture in intertidal zone. Annex 3 describes briefly the indications of the feasibilities of the species/culture systems. At the end of the table are a brief assessment and a provisional rating of a species/culture system's priority as a pilot project.

B. Technical options: a structured R and D programme for potential pilot aquaculture projects

The above analysis of feasibilities and constraints to eight of the nine potential pilot production systems now gives the basis for a structured technical programme for each species. The technical programme should consist of seven R&D areas:

1. Production technology, comprising broodstock, larviculture, nursery, grow-out and post harvest technologies,
2. Marketing,
3. Socio-economics and livelihoods ,
4. Fish health,
5. Environment,
6. Certification for food safety and quality,
7. Training and Extension.

The R&D areas are specified under the three priority species that have been provisionally identified for pilot development, namely, milkfish, tilapia and freshwater prawn. (The same scheme can apply to any additional species such as siganid, seaweed and Pacific oyster).

Table 2. Structured R and D programme: an outline

R&D area/ Species	Milkfish	Tilapia	Macrobrachium
1. Production Technology			
1.1 Broodstock	Not applicable	Select and maintain broodstock from population in a local facility Introduce improved broodstock of silver and red strains.	Trial in Aitutaki marine centre on broodstock maturation.
1.2 Larviculture	Not applicable	Hatchery establishment, and training in management and operation.	Short term – import seed Long term- seed production depending on results of broodstock development.
1.3 Nursery	Acclimation of fry. Live food production. Feed formulation.	Feed and feeding trials. Development of nursery facilities in some farmers' farms.	Feed and feeding trials. Diet formulation.
1.4 Grow-out	Livefood production (primary productivity).	Feed development from local materials. Feed and feeding trials.	Diet formulation.
1.5 Post-harvest	Preservation of freshness. Transport and refrigeration. De-boning. On farm packing.	Chilling, transport and refrigeration, live transport to resort hotels and restaurants.	Fresh product form, live transport to hotels and restaurants.

2. Marketing	Product form preferences. Product development (smoked, dried, de-boned). Promotion campaigns (recipes, cooking demonstrations, displays at supermarkets). Packaging Market research.	Product form preferences and development (smoked). Promotion campaigns for tilapia recipes, cooking demonstrations, displays at supermarkets. Farm gate sales Market research.	Recipes, cooking demonstrations, displays in aquaria of restaurants. Farm gate sales.
3. Socio-economics, livelihoods	Cost and returns studies Cost-benefit analysis. Cost efficiency improvement. Risk management.	Cost and return studies. Cost efficiency improvement. Segmentation of operations for more job opportunities and higher technical and economic efficiencies (hatchery/nursery/grow-out). Farmers' associations.	Cost and return studies. Cost efficiency improvement.
4. Fish health	Quarantine and certification, water quality maintenance.	Quarantine, certification, better management practices.	Quarantine, certification.
5. Environment	Risk analysis and management. Monitoring of water quality of ponds, pools and lakes.	Risk analysis and management. Effluent (water and sludge) management.	Risk analysis.
6. Certification (food)	Food safety. Good aquaculture practice. Hazard analysis and management.	Food safety. Good aquaculture practice. Hazard analysis and management.	Food safety.
7. Training and extension	Capacity building for both technical staff of MMR and farmer groups. Workshops and seminars of various stakeholders. Scientific and professional meetings. Better management practices manuals. Technology handbooks. Training manuals. Training courses. Development support communications (mass media, website, seminars, technical briefs).	Capacity building for technical staff and farmer groups. Workshops and seminars of various stakeholders. Scientific and professional meetings. On farm training and demonstration. BMP manuals. Technology handbooks Training manuals. School practicum. Communications support (mass media, seminars, technical briefs).	Capacity building for technical staff and farmers. Workshops and seminars of various stakeholders. Scientific and professional meetings. On farm training and demonstration. Technology handbooks and training manuals, Communications support.

C. Strategic options

1. Short Term

The short term goal of the aquaculture development program is to demonstrate the viability of selected aquaculture projects to encourage adoption by the private sector. The basic approach is to hurdle the constraints to survival and growth, then address the technical constraints to selected aquaculture production systems and species. Having done these, the next step is to demonstrate that these systems are profitable for the farmer. An additional analysis might be to determine if the aquaculture development project on any of these species provides an acceptable cost-benefit ratio to the national economy. In short, the goal is to determine that farming the species is profitable for the farmer and beneficial to the community.

2. Long Term

The longer term strategy is to up scale the pilot production projects into commercially viable enterprises and promote their wider adoption by individuals, farmer groups and communities. The long term goals are to provide a sustainable alternative to capture fishery that assures food security to the communities, create more job opportunities in these communities, and contribute to the resilience and adaptive capacities of island communities to the potential impacts of global warming.

3. Project vs. Programmatic Approach

There are basically two ways to go forward, which are not mutually exclusive: the project or the programmatic approach. The first would mean developing and implementing one or two higher priority pilot projects, the second would entail formulating a program comprising several projects that are linked and which are implemented either simultaneously or in an appropriate sequence.

The purposes and attributes of either option are:

- **Option "a"** would serve as a learning project for InFAD technical personnel and the cooperating farmer or farmers group,
- Project would serve as a demonstration and learning case for interested farmers,
- It would require less start-up resources,
- Management and technical assistance can be concentrated,
- It might be easier to find government and/or donor assistance to help fund its implementation.
- The results of the project would inform the management and technical aspects of succeeding projects.
- Monitoring and evaluation would be very specific to the project's processes and outputs.
- The outcome is a demonstrated viable farming system for wider promotion to producers and communities and can serve as a template for succeeding projects.

- **Option "b"** would be, as the concept suggests, a "programmatic model".
- It offers a broader perspective and a holistic rather than piecemeal development approach.
- Its component projects could be several projects on one species and different culture systems located in different islands (for instance a focus on milkfish consisting of pilot projects in Rarotonga, Atiu and Penrhyn as well as Manihiki) or several projects on different species and culture systems (such as milkfish, freshwater prawn, tilapia and siganid) located on different sites and islands.
- This option does not mean implementing all projects at one time; their implementation could be phased according to a prioritization scheme.
- The merit of this option is that there is an overarching framework to guide individual projects.
- The outcome is a master development programme for aquaculture.

V. Summary of findings and recommendations

This summary is in line with the Terms of Reference of the Mission.

1. Findings

- Review of the past and current national fisheries policy, management, development and strategic plan, in particular sustainable aquaculture development in Cook Islands.

  1) A strategic plan is in place for aquaculture under the MMR corporate plan. A logical framework, while incomplete, specifies clearly the outcomes and their indicators.

  2) The Plan is supported by a systematic filtering and scoring model to aid in establishing priorities among the different candidate species. It has been tested and used to indicate the potential impact of each species and the chances of its success. The system identifies constraints to successful development of the species and ways to overcome the constraints.

- Assessment of the impact of aquaculture development to date in CI, including technical, economic, social, environmental and institutional aspects.

  1) Aside from pearl oyster farming, which developed into a major industry, the initiatives to develop the aquaculture of finfish, freshwater prawn and seaweed have not yielded any sustained economic impact. There was no opportunity to upscale the trials into commercial ventures and therefore no evidence of profitability could be given to prospective farmers. The main reason is that the trials focused on the biological and technical feasibilities of culturing the species and did not assess their profitability. (Refer to Section III).
  2) The trials yielded a number of strategic, management and technical lessons to inform further pilot projects. They also provided some experiences in project management for MMR technical staff and management and technical issues that need to be addressed by farmers. (Refer to Section III).
  3) The marine research centres in Tongareva and Aitutaki have improved capacities for research and development in pearl oyster culture, trochus and giant clam hatchery and grow-out. The Tongareva facility, when rehabilitated, could be used to support some activities in milkfish culture in the pools around Penrhyn. The marine research centre in Aitutaki has a staff and the facilities for broodstock development and hatchery of freshwater prawn and to support exploratory trials in Pacific oyster grow-out.

- Assessment of adequacy of funds and resources for aquaculture development for improving sustainable aquaculture development in CI.

  1) The technical capacity of the current staff for aquaculture in MMR would be sufficient to oversee pilot development projects. Project planning is a fairly strong point. There would be need for some capacity building for establishing, operating, monitoring and evaluating pilot development projects (Refer to Section II).
  2) There is very little budget allocation for on-farm research on production systems, which is the reason the MMR worked with cooperators who provided a large portion of the resources. A coordinated pilot development programme would require technical assistance and funding support for training, start-up operations, sourcing and acquisition of seed, and some equipment. The establishment of essential facilities like a small hatchery (for finfish) would need some external assistance.
  3) Capacity building for farmer cooperators as well as MMR technical staff for pilot project implementation will require some external assistance in the form of expertise and supplementary funding to government allocation and farmers' or communities' in kind contributions.

2. Recommendations:

- Recommend how planned aquaculture development, activities and projects should be designed to further improve its effectiveness, development impact and sustainability.

  1) The government has made important headway in screening the candidate aquaculture species. From this output, it is suggested that a structured R&D programme be formulated for the species and farming systems identified in this mission. The economic, social and environmental justification for projects could be derived from this section. Table 3 identifies the technical areas on which to base the priorities for an R&D programme for each species.
  2) A choice between focusing on specific stand-alone projects and going for a programmatic approach has to be made. Experiences in aquaculture development and management in the Asian region provide evidence that favour a programmatic approach. Aside from the arguments for it provided in the Section, it also allows a greater opportunity for broader collaboration among various organizations.
  3) Section IV B suggests a framework for an R&D programme for aquaculture development. It includes the technology components of the aquaculture production system, namely, Production, Marketing, Production technology, comprising broodstock, larviculture, nursery, grow-out and post harvest technologies, Marketing, Socio-economics and livelihoods, Fish health, Environment, Certification for food safety and quality, and Training and Extension.

- Recommend appropriate technology packages and preliminary outline designs for pilot-scale tilapia and freshwater prawn farming in Cook Islands.

  1) Section IV provides the elements and basic information, including expertise required and indicative costs of some inputs, to design pilot projects for specific production systems of milkfish, tilapia and freshwater prawn culture in identified sites.
  2) The potential objectives and outputs of the pilot projects are indicated in Section IV, B. The immediate objective is to demonstrate the economic viability of an aquaculture production system and the development objective is to upscale the successful pilot project into a commercially viable enterprise for wider adoption. The long term objective is to provide sustainable food for the local population and a buffer to decreasing catch and increasing costs, and improve the resilience of island communities to the impacts of climate change.
  3) The outputs are (i) the proof of biological feasibility of a species and its production system is established, (ii) technical and management requirements of producing and marketing the products of a production system are developed, and (iii) technical and management requirements for an aquaculture system that is profitable to the producer and beneficial to the community and country are developed.
  4) The envisaged outcome is an up scaled commercial model and its adoption by more farmers and communities.
  5) A draft concept for a pilot project on tilapia aquaculture development, with three components.
  6) A draft concept for a coordinated aquaculture programme composed of several projects.

VI. The Stakeholders Consultation Workshop

The final activity of the mission was a discussion of its findings and recommendations at the stakeholder's consultation workshop held on 24 July.

The major outputs of the consultation were (i) the identification and pre-assessment of the feasibility of five species in nine production systems for pilot testing, (ii) a provisional priority setting for pilot testing of each production system, and (iii) a set of recommended follow up actions and the responsible party or parties for each action. The feasibility indications of identified species and systems appear as Annex 3.

Annex 1

Persons consulted and met during the mission

1. Ian Bertram, Secretary of the Ministry of Marine Resources
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2. Koroa Raumea, Director of Inshore Fisheries and Aquaculture Development
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3. Tap Pryor, Aquaculture farmer and Head of the Titikaveka Growers Association
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4. Mark Makuri, Pearl farmer, Manihiki Island

5. Aneru Tautu, former Mayor of Atiu Island

6. Sonny Tatuava, Senior Fishery Officer (Extension), Community-based Fisheries Programme. InFAD, MMR
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7. Temu Okotai, former Chief of Staff of the Prime Minister's Office (1992-99), entrepreneur in the tourism sector, resident of Manihiki
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8. John Ngaata, prospective farmer, resident of Rarotonga, with interest in oyster farming

9. Bruce Manuela, Director, Northern Cook Islands Fishing Co., with office in Rarotonga
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10. Timothy Pickering, Aquaculture Specialist, SPC, Noumea New Caledonia

11. Izumi Masanami, Fisher Officer, FAO SAP, Apia, Samoa
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Annex 2

Lessons from previous initiatives

Project	Lessons		
	Strategic	Management	Technical
1. Milkfish seed transfer and on farm grow out trial	Need to establish a reliable seed resource and assure sustained supply. Importance of an agreement with specific clear responsibilities of cooperating parties (i.e. MMR and farmer cooperator/s) on the management and conduct of the on-farm trial Strengthening the capacity of farmer cooperators Improving the capacity of field staff ("Full understanding of any marine and freshwater aquaculture species grow out, namely, tilapia, milkfish or prawns"; "giving staff basic related knowledge for biology and environmental issues related to aquaculture grow out principles".)	A positive lesson is the conduct of a diagnosis of the problem that has occurred to identify the specific problem areas and what could have been done in order to inform future activities. Staff coordination Logistics of transfer and acclimation	Biological feasibility established - growth rates measured. However, feed and feeding effects not isolated in the monitoring. Effect of low average water temperature needs to be factored in. Handling problems identified: need to reduce stress from improper handling (proper fry/ fingerling collection procedures; correct density in container, water quality, oxygenation, and packing). Markets identified - local, tourists, probably export Cost and returns not carried out. Recall data indicates a farm gate price of NZD5 per fish (or 2 fishes) at average size of 198 g.
2. Tilapia culture	Risk analysis, certification, quarantine are essential. As with the milkfish trial, there is need for a specific agreement showing clear responsibilities between MRR and the farmer cooperators	The assessment of survival, growth and marketability of the product and value addition was a positive lesson. Survival was relatively high (ca 60-70%), growth rate was low probably due to low water temperature and quality (sediment accumulated), and poor nutrition; all fresh fish harvested was sold and smoked fish had interested buyers,	As initial production from farm trial showed, the fish can be acceptable to segments of the population. Probably poor local market due to species preferences of local people but promotional campaign could improve demand. On-farm trial showed poor growth; cost and return analysis was not carried out. Recall data gives a price per fish (or 2 fishes) of NZD5 at farm gate at average size of 190 g.
3. M. rosenbergii: introduction and grow-out culture	Climate risk was revealed as having a major (in fact catastrophic) impact: drought stopped the project and discouraged further activities;	Feed had to be imported with the seed but local substitute could have been developed	Biological feasibility established - stock grew to market size and growth rate measured Local demand was proven; harvest was sold. Cost and returns not carried out. However, the harvest was sold for NZD40-50 per kg. In 1994-95.

4. Seaweed: establishment of on site trials	Overall lesson from the 2001 seaweed trial is the importance of risk assessment and identifying mitigation and management measures. The trial, in hindsight, showed that these risks, for example, should have been assessed before the project was launched: • Biological risk - predation • Natural risks - exposure to strong winds, • Social risks - community's perceptions Some constraints were identified before the project from previous experiences i.e. (i) Damage to lines and loss of crop during storms; (ii) high maintenance labor demand and relatively low returns to labor; and (iii) the generally low price of dried seaweed in the world market. Others revealed but not foreseen by the project conducted in 2001 (by Luxton) include: • The critical role of community relations, community interest and participation, and "ownership". .	Importance of knowledgeable field staff for on site trouble-shooting Need for facilities for "seed" acclimation The critical role of a good logistics - transport, schedules, on-board facility to preserve seed viability, emergency back-up facilities. Need to establish and maintain seed stock nursery as a source for subsequent trials; this removes the need to go out again to collect from natural stocks, which the project has illustrated as an expensive and time consuming exercise. Effect of poor project communications on field operations	Poor economic viability established - a feasibility study undertaken in 1997 (by Luxton) estimated that the net returns per hour of labour input were likely to be of the order of $1.87 at which level it may not be highly attractive to many islanders. Technique for seed transport to ensure viability Water quality of site - nutritive content Water circulation at site - lack of flushing Presence of predators and mitigating their damage
5. Pearl oyster – impact of the economic downturn and disease problem	The need for a strong farmers association has been highlighted by adverse economic conditions.	Crucial importance of best management practices emphasized by the extensive vibrio infection.	Importance of maintaining market competitiveness stressed (promotion, quality, and cost of production). Need for trained local technicians for specialized skills.

Annex 3

Indications of feasibilities and priorities

The species and systems and potential sites

1. pond culture of milkfish in Raratonga,
2. stocking and grow out of milkfish in a brackishwater lake in Atiu,
3. stocking and grow out of milkfish in brackishwater pools around Penrhyn,
4. hatchery and tank culture of *O. niloticus* in Raratonga,
5. pond or tank culture of *O niloticus* in Atiu,
6. pond or tank culture of *M. rosenbergii* in Atiu, (7) polyculture of *M. rosenbergii* and tilapia in Atiu, and
7. tank culture of silver rabbitfish in Rarotonga
8. Pacific oyster trial

A. Milkfish

1. Pond culture of milkfish in Rarotonga

Biological feasibility	Technical Feasibility	Economic viability
Growth – can grow but low water temperature is a constraint. Reproduction – may not reproduce as the Mitiaro trial has found	Seed supply - none locally, has to be shipped from Manihiki or imported from Asia (Indonesia, Taiwan) Feed supply - artificial feed available for importation; natural food can possibly be grown: "Lab-lab" a zoo- and phytoplankton mat that milkfish graze on as natural food might grow in the lower Rarotonga temperatures. Growth of "lab-lab" is a function of the reaction of the photosynthetic effect of sunlight to the organic content of the soil. "Lab-lab" culture in tanks is possible but difficult (from SEAFDEC AQD research). Soils with high clay content are put in the tank at 4 inches thick then let "lab-lab" grow. Soils with high clay content support the best growth of "lab-lab". Growth of "lab-lab" is directly related to the amount of organic matter present in the soil. The problem for "lab-lab" growth is the unpredicted rain because they can easily disintegrate. An alternative is filamentous algae, as in the Palau bait production, because of unpredictable weather. Technology - Breeding, not applicable - Hatchery, not applicable - Grow-out - management skills available - Harvest and post harvest: fresh, chilled or semi processes Market: tourists, local population, institutional buyers Labour: workers need to be trained Capital: large outlay needed for moving or importing seed.	Local price is fairly high. Local demand from tourists and local population can be steady to support a good market price. Experience from the trial showed that the farm output was sold quickly. Profitability is not known; the cost of seed transport is very high (in the Mitiaro project, collection, handling and transport cost totaled NZD4,000 for 2,000 fingerlings).
Overall assessment: Major constraint remains to be the supply of seed. The trial showed low growth performance but this could be improved with good feeding, water quality maintenance and other good management practices. Plus factors are a fairly large local market and the prospect of wider adoption by the other members of the TGA, al coal growers association. The other positive point is the presence of a well-equipped aquaculture facility (that of Mr Tap Pryor) thus removing the need to build a demonstration farm. **Provisional priority rating: moderate**		

2. Stocking and grow-out of milkfish (as food) in Lake Teroto, in Atiu

Biological feasibility	Technical Feasibility	Economic viability
Growth – Pond culture trials in Rarotonga and seeding trials in Mitiaro are evidence it can grow in Lake Teroto Reproduction – likely unable to spawn in this latitude Presence of eel is a predation risk to fry that are newly stocked.	Seed supply - from outer islands i.e. Manihiki; or from other countries (Indonesia, Taiwan). Feed supply - primary productivity of the lake, which is not known; likely competition from the established population of mosssambicus. Technology - Breeding - not applicable - Hatchery - not applicable - Grow-out - experience in Mitiaro, - Harvest and post harvest - fresh fish or semi-processed (gutted and dried). Harvesting could be a problem. Market - tourists to Atiu, small local population. Labour - skills not available Capital - inter-island transport or importation costs are high	Market - a fairly good market price in the local and tourist markets. Demand would be very low from a low population base. Profitability, because of the communal nature of the system may not be an appropriate measure, but a cost-benefit analysis that factors in the relative costs of fish supply from the lake and from capture fisheries may give a better indicator. Lake culture would reduce cost of feed and electricity to zero.
Overall assessment: Milkfish has been rated of medium benefit and medium chances of being successful under MMR's scoring model. Constraint is the same as the Mitiaro trials: need to transport fry, which is expensive. The plus factors are the availability of a natural water body that appears productive and the interest of the community. And unlike pond culture, feeding cost would be zero. **Provisional Priority rating: Moderate**.		

3. Stocking and grow out of milkfish (as bait) in pools in Penrhyn

Biological feasibility	Technical Feasibility	Economic viability
Growth –well demonstrated from local experiences Reproduction – spawners are found in the waters of the Island	Seed supply - abundant, readily available, no long distance transportation needed Feed supply - natural productivity; need carrying capacity assessment of the pools around the island Technology - Breeding, not applicable - Hatchery, not applicable - Grow-out, stocking density will depend on carrying capacity; management of pools to improve primary productivity, and management of stocked fish can be .learned. - Harvest and post harvest - fresh, packed and refrigerated or live bait Market - 20 tuna longliners operating in the area, a rapid turn-over is expected. Labour - family, local labour Capital - low start-up capital needed	Baitfish price in Pago Pago is NZ$ 2000 per ton. The low production and very minimal transport cost could make tuna bait production a profitable enterprise. Social benefits could include creation of employment opportunities to arrest outmigration, or as a fallback to out-of-work returning émigrés.
Overall assessment: Milkfish production is rated medium in impact and medium in the potential of success by the MMR rating system. Profitability could prove very high, but direct beneficiaries are not many, although the social benefit could be significant and there could be significant savings for the country as well. **Provisional Priority Rating: High**		

B. Tilapia

4. Hatchery and tank culture of *O. niloticus* in a school site (Papaaroa College) in Rarotonga

Biological feasibility	Technical Feasibility	Economic viability
Growth – slow but can be improved with good nutrition and management Reproduction – natural, in earthen pond.	Seed supply - all male tilapia needs importation; but can be produced locally with hatchery support. Broodstock development and hatchery production are possible. This will need a hatchery, which is non existent and the skills for which will need to be taught. Some of the current stock of GIFT tilapia in Mr. Pryor's pond could be selected for broodstock development. Improved broodstock can be acquired subsequently from Thailand, Philippines or Hawaii. Feed supply - may need to be imported, but farm grown feed could be developed. Technology - Breeding, known and can be taught - Hatchery, available and can be taught - Grow-out, farmer experience, management techniques can be acquired from training and published information - Harvest and post harvest - fresh fish, smoked Market - probably an initially low local demand, some potential for tourist Labour, available Capital - broodstock introduction and maintenance, hatchery facility, tanks for holding broodstock and for culture need to be set up.	Demonstrated demand from local population. Price of the fresh and smoked fish harvested from the farm trial was acceptable.
Overall assessment: Major constraint is seed supply but a stock is now existing from which broodstock can be selected. Some plus factors are a potentially good market in Rarotonga from some segments of the population. A large positive is the presence of an aquaculture farm that can serve as training and demonstration farm, as a nursery for introduced fry before they are distributed, and the potential adoption of tilapia farming by members of the TGA. The high water table in the area could be an advantage. **Provisional Priority Rating: Moderately high**		

5. Pond culture *O niloticus* in Atiu

Biological feasibility	Technical Feasibility	Economic viability
Growth – would be slow using the Rarotonga trial as reference Reproduction – will reproduce naturally	Seed supply - importation Feed supply - importation, possibility of home made formulation Technology - available - Breeding - available - Hatchery - available - Grow-out - available - Harvest and post harvest - fresh and semi processed Market - small but available; smoked tilapia is selling well in Atiu Labour - community Capital - fairly significant	Market - prospective markets include the populations of Atiu, Mauke and Mitiaro. Initial investment for a small hatchery would be fairly high, including costs of training and broodstock. Cost-benefit ratio might be unfavourable over a short discounting period; Cost and return could yield a positive profitability.
Overall assessment: Tilapia is low impact - moderate potential for success under MMR's scoring system. The constraint of seed cited for the Rarotonga pilot project also applies to Atiu. And unlike Rarotonga, pond or tanks have to be constructed. -The plus factor for an aquaculture production is provided by the increasing cost of fishing from high fuel costs and the diminishing nearshore resources (i.e. a higher cpue). The keen interest of the community can also be considered. **Provisional Priority Rating: Moderately high**		

C. Freshwater prawn

6. Pond culture of Macrobrachium *rosenbergii* in Atiu

Biological feasibility	Technical Feasibility	Economic viability
Growth –proven to reach marketable size in a previous on farm trial. Reproduction – no trial done any record or observation of natural spawning in pond.	Seed supply - import Feed supply - local raw materials available for farm feed formulation, import of artificial diet Technology - Breeding - known and accessible - Hatchery - backyard operation possible, as in Thailand and Malaysia - Grow-out - technology and techniques accessible - Harvest and post harvest - fresh product form Market - local population, tourists, institutional buyers Labour - skilled labour available, training Capital - significant outlay for seed importation	Consumers have been shown to be willing to pay a premium price. Profitability - unknown
Overall assessment: Marketability and a high local price favour a pilot production project. Constraint is seed supply; cost of imported seed might offset the economic advantage of a high product price. A plus factor is that the potential source of seed - Tahiti - is near with direct air links with Rarotonga. Another constraint is feed; imported diets would increase operating costs. MMR rating gives freshwater prawn culture a **medium** potential impact and a **medium** potential for success. **Provisional Priority Rating : Moderately high**		

7. Polyculture of *M. rosenbergii* and tilapia in Atiu

Biological feasibility	Technical Feasibility	Economic viability
Growth – both species reach marketable size in separate cultures. Proper stocking technique can avoid predation of prawn on tilapia fingerlings. Competition for food may occur.	Seed supply - import Feed supply - local raw materials available for farm feed formulation, import of artificial diet Technology - Breeding - known and accessible - Hatchery - backyard operation possible as in Thailand - Grow-out - polyculture of - Harvest and post harvest - fresh product form Market - local population, tourists, institutional buyers Labour - skilled labour available, training Capital - significant outlay for seed importation	Market - has been shown to be willing to pay a premium price. The high cost of feed and seed as well as electricity may impact severely on profitability
Overall assessment: As with Rarotonga, marketability and a high local price favour a pilot production project. Demand would be lower from a very low population but the product could be shipped to Rarotonga. Constraint is seed supply; cost of imported seed might offset the economic advantage of a high product price. A plus factor is that the potential source of seed – Tahiti – is near with direct air links with Rarotonga. Another constraint is feed; imported diets would increase operating costs. MMR rating gives freshwater prawn culture **medium** potential impact and **medium** potential for success. **Provisional Priority Rating: Low**		

iv. Other species

8. Culture in tanks of silver rabbitfish *Siganid argenteus*

Biological feasibility	Technical Feasibility	Economic viability
Growth – very slow. Information on other siganid species can be cited to provide an indication. *Siganus argenteus* is one of the slow growing siganids to be cultured in a grow-out scale. It has a similar growth rate performance with *Siganus fuscecens.* This species slow growth performance has been verified by SEAFDEC AQ in a cage (5m x 5m x 3m). Average body weight (ABW) of 97.65 grams in 11 months was attained from an initial ABW of 16 grams. Similar slow growth rates in siganids were experienced in Philippines and Palau.	Seed supply - abundant in the local waters Feed supply - none locally, technique for natural food production be provided, artificial food Technology: accessible - Breeding: available from elsewhere - Hatchery: not applicable - Grow-out: available from elsewhere; feed and feeding is critical, technique to grow natural food is available - Harvest and post harvest - fresh fish supplied to restaurants and supermarkets, dried product may be acceptable, as in the Philippines, where it commands a high price. Market: tourists, local population, institutional buyers (restaurants, hotels) Labour: available but management skills for the species need to be acquired	The tourist market would absorb production and may be willing to pay a premium price. It may not be economically viable owing to a very slow growth. Based on the growth performance of *S. fuscecens* and its market value of USD2.00/lb. in Palau, commercial scale production is **not feasible**
Overall assessment: Major biological constraint is the poor growth performance of species, likely poor economic viability. Even if cost and return is positive, the slow turnover would mean a long payback period. Plus factors are an abundant source of seed (no need to import or introduce), the high value of the fish and a potentially good local market, availability of technology for its culture, and presence of a facility for its trial. **Provisional Priority Rating: Low.** Trail can be done by farmer with technical advice.		

9. Culture of Pacific oysters *Crassostroea gigas*

Biological feasibility	Technical Feasibility	Economic viability
Growth – terminated in an artificial conditions Unknown in Cook Island natural environment.	Seed supply - spats from NZ Natural food - probably very low in CI waters Technology: accessible - Polyploidy - Grow-out facilities (racks) - Harvest and post harvest Market: tourists, local population, institutional buyers (restaurants, hotels) Labour: management skills can be learned from NZ	If it can be grown, profitability is likely high.
Overall assessment: An apparently suitable site in Aitutaki for production trials should be assessed. It might also need negotiations with the island council to sue the area for production trials. **Provisional Priority Rating: Low.** Low scale trial can be done.		

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