

SPC Aquaculture Technical Papers



REGIONAL ASSESSMENT OF THE COMMERCIAL VIABILITY
FOR
MARINE ORNAMENTAL AQUACULTURE
WITHIN
THE PACIFIC ISLANDS

(GIANT CLAM, HARD & SOFT CORAL, FINFISH, LIVE ROCK & MARINE SHRIMP)

by

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Aquaculture Section
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TABLE OF CONTENTS

1. Acknowledgements	4
2. Acronyms and Abbreviations	4
3. Executive Summary	5
4. Recommendations	7
5. Introduction	9
5.1 Background to the Report	9
5.2 Report Methodology	9
6. Overview of Aquaculture for the SPC Pacific Island Countries	10
7. Global Marine Ornamental Trade	11
8. Pacific Region Marine Ornamental Trade	12
9. Pacific Region Aquaculture Marine Ornamental Commodities	13
9.1 CITES	15
10. Aquaculture Commodity Assessment	16
10.1 Giant Clam	16
10.2 Live Coral	20
10.3 Live Rock	22
10.4 Marine Finfish	23
10.5 Marine Shrimp	24
11. Economic, Financial Assessment and Opportunities	25
11.1 Markets for Marine Ornamental Aquaculture Commodities	28
12. Marine Ornamental Aquaculture Commodity Developments, Concerns and Constraints	29
13. References	33
14. Appendices	37
14.1 Appendix 1: Terms of Reference (TOR)	37
14.2 Appendix 2: Background Reports	38
14.2.1 Federated States of Micronesia	39
14.2.2 Marshall Islands	46
14.2.3 Palau	53
14.2.4 Fiji	59
14.2.5 Samoa	67
14.2.6 Tonga	74
14.2.7 Vanuatu	80
14.2.8 American Samoa	85
14.2.9 Cook Islands	87
14.2.10 Kiribati	89
14.2.11 Papua New Guinea	91
14.2.12 Solomon Islands	93
14.2.13 Tuvalu	96
14.3 Appendix 3: List of Agencies and Organizations	98
14.4 Appendix 4: Travel Itinerary for Consultants	99

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2. ACRONYMS AND ABBREVIATIONS

AIG	Alternative Income Generation
CITES	Convention on International Trade in Endangered Species
CROP	Council of Regional Organisations in the Pacific
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organisation of the United Nations
FFA	Forum Fisheries Agency
FSPI	Foundation of the Peoples of the South Pacific - International
FSM	Federated States of Micronesia
GDP	Gross Domestic Product
LA	Los Angeles
MAC	Marine Aquarium Council
MIMRA	Marshall Islands Marine Resource Authority
NGO	Non Government Organisation
OFCF	Overseas Fisheries Cooperative Foundation
PNG	Papua New Guinea
RMI	Republic of the Marshall Islands
SOPAC	South Pacific Applied Geo-Science Commission
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environmental Programme
TOR	Terms of Reference
UN	United Nations
USA	United States of America
USP	University of the South Pacific

3. EXECUTIVE SUMMARY

The Pacific region consists of 22 countries and territories which encompasses 2,700 islands. Coral reefs dominate the inshore marine ecosystems and provide both subsistence and commercial income opportunities. Increasing populations and urbanization creating related needs for cash incomes have placed ever increasing demands and pressures on the regions coastal resources. Striking the balance between environmentally sound reef resources and economically viable marine industries is important to secure long term income generation and better standards of living for the people of the region. The Pacific Island states have identified the mariculture of marine ornamental commodities as potential opportunities that can be further developed to meet these objectives.

Work on the review by the consultant team took place between July and November 2003. The review team visited the Marshall Islands, Federated States of Micronesia, Palau, Samoa, Fiji, Vanuatu and Tonga and undertook meetings with relevant government agencies, non government organisations, private sector marine exporters and aquaculturists. Discussions by telephone, fax and email were undertaken with individuals and agencies in six other Secretariat of the Pacific Community (SPC) countries. Country visits were based on current levels of activities associated with the marine ornamental trade. Additional desk study summaries of the remaining Pacific nations that have been involved in this trade have been included. Information obtained for this review was sourced from a wide range of publications and stakeholder discussions including regional and government agencies, communities, NGOs and private sector companies and individuals.

This review has been undertaken to provide a regional assessment of the level of marine ornamental commercial culture as well as the economic and the biological viability of culturing marine ornamental commodities to supply the export demand for the international aquarium markets. We were also tasked to recommend mechanisms and approaches that can be undertaken to enhance the production of existing and new aquaculture commodities for the member countries of the Secretariat of the Pacific Community (SPC). Specifically, six aquaculture commodities were assessed (giant clam, hard coral, soft coral, fish, live rock and shrimp).

An economic assessment was undertaken to provide an insight into the region's opportunities and constraints to develop marine based industries and information has been provided on current demands for each aquaculture commodity currently cultured within the region. Economic opportunities are closely related to marine and coastal resource endowments of each nation, which vary considerably within the region.

The wild collection and subsequent export of marine commodities for the international marine ornamental trade is currently an ongoing successful income earning industry and a provider of employment within the region. The industry has expanded over the past decade with some of the Pacific island countries that have access to international air transportation links actively participating in the industry. Fiji dominates the industry within the Pacific with a market share of approximately 75 percent of all trade, annual export earnings of US\$19 million (2001) and currently employs over 1,000 individuals.

The marine ornamental industry is, however, based on resource extraction (approximately 95% by volume), and issues about the long term sustainability and health of these natural resources is a Pacific regional and global concern. Management protocols throughout the region are under development to provide a mechanism to allow the sustainability of the wild collection industry. Wild collection commodity replacement with aquacultured products is a viable alternative for organisms that can be cultured.

Marine aquaculture products developed for and traded in the marine ornamental industry from the Pacific islands is in its infancy and currently commands a very small share of the market compared to wild collected marine commodities originating from the region. In general, cultured products are labour intensive, have higher risk factors and incur time delays in profit earnings when compared

to the wild collection of similar products. Nevertheless, the further development of existing and new aquaculture commodities destined for the international marine ornamental industry is potentially a viable economic prospect for the Pacific Island region. The currently traded aquacultured commodities (giant clam, hard and soft coral and live rock) have established markets, albeit small, within this industry and it is envisaged that as quantity and quality of these products develop, market share, market acceptance and commodity prices will increase. Proven technology for the culture of marine finfish and marine ornamental shrimp has yet to be realised. The development of aquaculture commodities to compliment the correct utilization of wild harvested products will assist in the development of the industry within the region whilst contributing to the ecological sustainability and environmental integrity of the resources.

The annual export of giant clams both cultured and wild harvested from the Pacific over the past decade have been in the order of 20,000 to 35,000 specimens with approximately 85 percent wild harvested. Giant clams are cultured in the majority of Pacific Island nations and are the largest aquaculture commodity currently traded in the international marine ornamental industry. The culture of giant clams requires the use of land based hatchery facilities and ocean based growout sites. The smaller brightly coloured species of *T. crocea*, *T. maxima*, and *T. squamosa* obtain the highest prices and this demand trend is expected to continue in the foreseeable future. At the writing of this report *T. crocea* has yet to be cultured in commercial numbers. Tonga and the Marshall Islands to a smaller extent are currently the largest producers of cultured giant clams sold into the marine ornamental trade.

The production of cultured hard and soft corals is currently in its infancy and is limited. They are cultured commercially in Fiji, Marshall Islands and Vanuatu. Fiji has the largest commercial hard coral farm within the region with a current estimated production figure of 25,000 individual pieces made up of 40 different species. The demand for hard and soft corals in the marine ornamental trade is huge comprising a large proportion of all invertebrates traded. Demand for corals over the past decade has expanded annually with this trend envisaged to continue in the future. Cultured corals make up a very small proportion of products traded at the present time and therefore it is difficult to predict demand and market trends for these commodities. It is however envisaged that as production increases with a subsequent increase in product quality and diversification culture corals will assume a larger proportion of the market.

Cultured live rock is presently produced only in Fiji with an estimated 50,000 pieces under cultivation. Although the demand for live rock is large with demand increases considerably over the past decade, demand for cultured live rock is small and restricted to specialty markets. Price, quality and quantity of wild harvested rock currently available to the marine ornamental industry are not conducive to the development of cultured live rock. Demand by the industry for cultured live rock products may change if Asian and Pacific island nation producers adopt legislation that strictly controls or bans the wild collection of this product (e.g. Florida State, USA).

The current biological knowledge and economic activity undertaken clearly indicates that the culture of a limited number of marine ornamental commodities is an economic prospect for the Pacific region. However, additional development in all aspects of the industry is required before the industry goals can be fully attained. These include: Human Resources; Biological, Technical and Infrastructure; Marketing and Business, Policy, Management and Enforcement. Furthermore, an integrated approach including bilateral and multilateral donor organizations, regional agencies, national governments, NGOs and the private sector is required to successfully develop this industry. SPC through its Aquaculture Unit should take the lead role in coordinating the development of this industry. The exact requirements of each nation will vary depending on current activities in place as well as related capacities.

At present, regulatory mechanisms within the Pacific island nations are not meeting the requirements to sustainably manage this trade, for both wild and cultured commodities. Therefore, the development of user-friendly management systems, including quarantine and CITES requirements

need to be further developed to allow the industry to be sustainably managed for the long term. Concerns and constraints raised during stakeholder discussions throughout the region are highlighted and discussed within the text and a series of approaches are recommended to address these concerns.

A number of recommendations based on the results of this study have been presented. These have been provided to assist each nation and regional agencies to assess their capacity to develop this industry. Specific requirements that needed to be addressed have been highlighted throughout the text and summarized in the recommendation section below.

4. RECOMMENDATIONS

The following recommendations are provided to guide the development of a sustainable industry for aquacultured commodities for the marine ornamental industry. Stakeholders recommended that SPC, through its Aquaculture Unit, with assistance from regional donor agencies and countries, take on the responsibility and act as a lead agency for coordinating the development of this industry and to assist member countries with their specific requirements. These include:

- Promote an integrated approach including regional, bilateral and multilateral donor organizations, regional agencies, national governments, NGOs and the private sector to successfully develop a sustainable regional marine ornamentals industry. Long-term linkages between national and regional stakeholders and sectors need to be further developed.
- Provide development assistance in specific aspects of the industry, such as;
 - Human resource skill development,
 - Biological and technical aquaculture assistance,
 - Infrastructure development,
 - Marketing and business skills development, and
 - Policy and management plan development and implementation.
- Further develop the SPC Aquaculture Portal to provide up to date information on all aspects of aquaculture relevant to stakeholders in the region.
- Facilitate information exchange, technical knowledge and skill transfer to develop both hatchery and growout farming operations for existing and new aquaculture species suitable for the marine ornamental industry.
- Facilitate and support ongoing culture programmes for giant clam, hard and soft coral and live rock, and support the development of new aquaculture research and development programmes for commodities targeting the marine ornamental export market. Highlighted programme requests included:
 - Decrease total weight of cultured live rock,
 - Increase percentage of coloured mantle in cultured giant clams (*T. maxima*, *T. crocea* and *T. squamosa*) through genetic manipulation in hatcheries,
 - Improve product line of cultured hard and soft corals, species, shape, colour and form, and
 - Improve shipping, airfreight and handling protocols and procedures.
- Assist member nations to develop nation-specific legislative and regulative guidelines to streamline the process to allow wise use of the marine environment for aquaculture purposes. The development of a generic template should be considered, clearly highlighting customary and government ownership rights.

- Facilitate the collection and distribution of marketing information relevant to all aspects of existing and new aquaculture species.
- Facilitate the development of marketing linkages between national and regional sectors of the industry.
- Promote consumer awareness in export markets (e.g. USA) of cultured commodities, their significance in sustainable resource usage and protection of coral reef communities and biodiversity.
- Facilitate business training programmes for potential participant communities, businesses and individuals to assist in the viable technical and financial development of the industry.
- Facilitate access to funds through national and regional financial lending institutions, regional and international technical support agencies, and bilateral and multi-lateral donor countries and agencies to stimulate the development of this industry.
- Facilitate regional and national initiatives to further develop and to promote sustainable practices within this industry, including support for marine management protocols to monitor all aquaculture development issues and regional protocols and procedures to allow the movement of commodities within the region.
- Assist the development, in collaboration with national and private sector partners, of protocol standards and requirements (Eco-labeling) for aquacultured products produced and marketed by the regional marine ornamental industry, resulting in a certification programme that is internationally accepted, based on existing programmes and product requirements (e.g. CITES for clams and hard coral products).
- Facilitate and promote regional linkages among the different stakeholders in the industry through participating communities, cooperatives and other production units and business entities of the industry to assist its long term development at national and regional levels.
- Foster partnerships among regional agencies to provide the linkages that assist in the development of relevant aspects of the industry. These would include agencies, in addition to the SPC, such as; Forum Secretariat, FFA, SPREP, USP, SOPAC, MAC and FSPI.
- Assist and expand the current and potential development of freshwater aquaculture species that have high demand in the freshwater ornamental industry in SPC member nations that are endowed with suitable freshwater resources.

5. INTRODUCTION

5.1 Background to the Report

The Pacific region consists of 22 countries and territories that encompass 2,700 islands. The land masses throughout the region varies, from Papua New Guinea with 462 840 square kilometres, to the five square kilometre Pitcairn island, and includes many nations consisting of small, low lying archipelagos (Sant, 1995).

Given that aquatic habitat far exceeds land masses within the region the nations' communities are closely intertwined and depend on the resources of the marine environment to meet a wide range of direct and indirect social and income generation functions (Sant, 1995 & World Bank, 2000). Direct benefits include local subsistence, artisanal and commercial fishing, activities of distant water fishing nations, the collection and sale of curios, dive tourism and the collection and export of marine aquarium organisms (Forum Secretariat, 1999 & Sant, 1995).

Coral reefs dominate the inshore marine ecosystems within the region with high levels of biodiversity and species endemism. Coastal areas, however, are facing ever increasing pressures and demands as populations, urbanization and the need for cash incomes increase resulting in increased resource exploitation, pollution and coastal area degradation. Nevertheless, the development of environmentally sound and economically sustainable marine industries are important to secure long term income generation and better standards of living for the people of the region.

The collection and subsequent export of marine invertebrates and vertebrates for the international marine ornamental trade has been an important source of income for coastal communities within the Pacific islands, and is a welcome provider of employment opportunities and export revenues (FAO, 2003a). Over the past decade this industry has been undertaken in many Pacific islands countries that have international air transportation links. Furthermore, the international demand for these products has steadily increased over the past decade, which has resulted in an expansion of the industry within the Pacific islands and globally.

However, this industry is based on resource extraction, and issues relating to the long term sustainability and health of these natural resources are a Pacific region and global concern. At present, regulatory mechanisms within the Pacific island nations are not meeting the requirements to manage this trade and therefore the development of user-friendly management systems need to be implemented to allow the industry to be sustainably managed for the long term.

Several regional initiatives are being developed to provide a mechanism to encourage all components of this industry to use best codes of practices to prevent natural resource degradation and to increase individual specimen health (e.g. Marine Aquarium Council - MAC) leading to an environmentally sustainable and economic industry. One proponent of these programmes is to culture the products destined for these markets. Aquaculture reduces or removes the need for wild resource extraction leading to enhancing the long term sustainability of the industry. Unfortunately, aquaculture techniques are limited to a small number of marine organisms which are currently sold into the marine ornamental trade. Further technological advances in animal husbandry and culture practices will provide the necessary information required to expand the demand for aquaculture commodities.

5.2 Report Methodology

The goal of the Secretariat of the Pacific Community (SPC) aquaculture work programme is to provide a regional support framework for sustainable economic, social and environmental aquaculture planning, research and development by Pacific Island governments and the private sector (SPC, 2002). Through regional stakeholder meetings (2002) it was clearly identified that one of the important attributes for the successful development of aquaculture is the need for a market-driven approach for all ventures to succeed. Therefore, the aim of this consultancy is to provide a regional

assessment of the commercial viability of marine ornamental aquacultured commodities, within the member countries of SPC, to supply the aquarium export market. Specifically, six commodities were assessed (giant clam, hard coral, soft coral, fish, live rock and shrimp).

To address the Terms of Reference (Appendix 1) two interconnecting output reports have been compiled: A Status Review and Evaluation Report, and a Background Report, the latter appearing as an appendix of the former.

The geographical scope of the consultancy is to provide an overview of aquaculture commodities associated with the international marine ornamental industry in all SPC member Pacific Island nations. Seven countries were identified as leading nations in this field and were visited by the consultant team. This included; Palau, Federated States of Micronesia, Marshall Islands, Samoa, Tonga, Vanuatu and Fiji. A detailed evaluation of each of these nations was undertaken by the consultant team and is documented in the background report located in Appendix 2. Information obtained included:

- Introduction to the nation.
- Geography of the nation.
- Aquaculture and environmental Legislation.
- Past and current marine ornamental culture activities.
- List of companies culturing marine ornamentals.
- List of supporting agencies.

In addition, brief background information (sourced from personal communications and published literature) has been documented for the following nations: American Samoa, Cook Islands, Kiribati, Papua New Guinea, Solomon Islands and Tuvalu.

The island nations of the Commonwealth of the Northern Marianas, Guam, Nauru, Niue, Tokelau, Pitcairn, Wallis and Futuna have not been included as each nation has no history in culturing aquaculture products for the marine ornamental trade. French Polynesia and New Caledonia have also been excluded as information was not accessed within the time frame of the consultancy.

6. OVERVIEW OF AQUACULTURE FOR THE SPC PACIFIC ISLAND COUNTRIES

Aquaculture is a relatively new activity within the Pacific islands, with a short history of less than 40 years, with the majority of programmes initiated on a short term external funding basis and limited traditional aquaculture knowledge and skills, except in very specialised instances and cultures (Adams et al., 2001). Regionally, aquaculture is of little commercial importance and contributes limited amounts to island Gross Domestic Products (GDP). One commodity exception is the production of black pearls from cultured black lip pearl oysters (*Pinctada margaritifera*) confined to the eastern Polynesian nations of French Polynesia and Cook Islands (Adams et al. 2001).

Nevertheless, aquaculture has been highlighted by the Pacific island governments and private sector companies as a potential avenue that could provide economic benefits, including local job creation, increase domestic protein sources, create import substitution, promote rural development, increase export earnings, and increase stock populations through restorations of capture fisheries (SPC, 2002). Through regional dialogue, eight priority species have been highlighted for aquaculture development within the Pacific islands, including; corals, giant clam, macrobrachium shrimp, milkfish, pearl oyster, sea cucumber, seaweed and tilapia (SPC, 2002). The first two commodities are directly associated with the marine ornamental trade. Furthermore, three broad categories have been highlighted in which aquaculture can be undertaken within the Pacific region. These include; Subsistence, Commercial and Restocking – Reseeding.

The Pacific region as a whole has many biological and economic attributes that favour the development of economically and environmentally sustainable aquaculture. Equally, the development of aquaculture within the region is constrained by numerous internal and external factors. Advantages and disadvantages for the development of aquaculture within the Pacific islands have been reviewed and discussed at length in Munro (1993a), De Silva (1998), Bell and Gervis (1999), Adams, et al., (2001) and SPC, (2002). Currently, giant clam, live rock and hard and soft corals are cultured within the Pacific islands for the marine ornamental market.

The future development of aquaculture within the Pacific region overall is likely to be associated with improvements in technologies, a wider range of species cultured and a more concerted effort to minimize environmental degradation. De Silva (1998) highlighted that technology developments in genetic selection, artificial propagation and larval rearing, nutrition and feed development, disease prevention and control, processing and marketing are likely to provide improvements to the Asian aquaculture industry through increased production and/or reduction in cost per unit of produce. These development criteria are equally important for the growth and sustainable development of the Pacific island aquaculture industry.

7. GLOBAL MARINE ORNAMENTAL TRADE

The international aquarium industry is a multi-billion dollar business. The annual worldwide wholesale trade in ornamental aquarium species (freshwater and marine) is estimated at about US\$900 million and the retail trade is estimated about US\$3,000 million (live animals for aquarium only) (Forum Secretariat, 1999, FAO, 2003a & Holthus, 2001). The aquarium hobby ranks second only to photography in popularity throughout the world.

The market for the ornamental industry is practiced mainly in industrial nations due to the costs involved in initiating and maintaining these systems which is especially relevant to the marine "coral reef" tank. The industry has steadily increased over the past decade, much of which is directly associated with advancement in aquarium technology and animal husbandry.

The markets for ornamental commodities are dominated by the United States, with an estimated 60 percent of the demand, with Western Europe (Germany, France and the United Kingdom), Japan, Taiwan and Australia responsible for much of the remaining percentage share (Holthus, 2001). It is estimated that over 11 percent of homes in America contain aquariums which represents some 95 million fish in 12 million aquariums, however over 90 percent of these are freshwater systems (Forum Secretariat, 1999 & Holthus, 2001).

Marine aquarium organisms are being collected and exported from most of the world's tropical seas. Philippines and Indonesia alone provide approximately 85% of the marine aquarium fish exported to the United States and Europe (Forum Secretariat, 1999 & Holthus, 2001).

Aquacultured commodities play an important role within the industry. Annual world turnover of ornamental fish aquaculture is estimated at US\$200 million with freshwater species representing approximately 90 percent in value terms against 10 percent for marine species (Forum Secretariat, 1999). It is estimated that 90 percent of all freshwater species destined for the ornamental trade are cultured. In comparison, just one percent of all marine species destined for this trade are cultured (Forum Secretariat, 1999).

The distribution network "chain of custody" for the ornamental trade is a complex system involving the following; fish collectors or breeders (aquaculturist), wholesalers, exporters, importers, trans-shippers and retail outlets. Due to the perishable properties of the aquarium industry commodities, airfreight transportation is a prerequisite. Air transportation cost within the industry is typically more than half of the landed product cost to the importer and therefore air freight availability and costs are an integral component of this industry. For the Pacific islands, limited airfreight services, distances to market for live products and freight costs dictate the financial profitability of operations.

8. PACIFIC REGION MARINE ORNAMENTAL TRADE

The Pacific nations' role in the international marine ornamental trade has significantly grown over the past decade with continued expansion expected. It is currently an ongoing successful income earning industry and a provider of employment within the region. The Pacific's contribution to the trade is unique and supplies the majority of live rock and live corals entering the United States and European markets with an estimated 19 percent of the value of trade for marine fish originating from the Pacific Islands (Holthus, 2001). Subsequently, the marine ornamental industry provides a valuable economic opportunity for Pacific island communities through direct village-based employment, income generation and export earnings.

Fiji dominates the industry within the Pacific with a market share of approximately 75 percent of all trade, with annual export earnings of US\$19 million for the year 2001 and currently employs over 1000 individuals. Regional estimates indicate that over 150 species of aquarium fish are traded by the industry with an estimated annual number of over 400,000 individuals exported, with Fiji alone averaging 260,000 individual fish exported annually. Over 50 species of hard and soft coral are exported within the region with annual estimates indicating between 120,000 and 200,000 individuals exported. Annual live rock exports for the region are estimated at 700,000 metric tons for 2003 with 95 percent of this originating from Fiji. Aquaculture products make up a small proportion of these figures.

Marine aquarium organisms are (or have been) collected and exported from the following SPC member countries: Fiji, Tonga, Vanuatu, Solomon Islands, Cook Islands, Marshall Islands (RMI), Palau, Federated States of Micronesia (FSM), Guam, Papua New Guinea (PNG), Samoa, American Samoa, Kiribati, New Caledonia and French Polynesia. A summary of marine aquarium commodities that have been traded within the Pacific region over the past decade is provided in Table 1.

Air freight cost (per kg of commodity) and availability vary considerably within the region, with the larger metropolitan nation's possessing cheaper freight options, more availability of flights and more availability of air freight space. The cost per kilogram of a commodity being shipped is a major component dictating the profitability of an operation however, the availability of air freight space or the lack of it is, for the majority of the Pacific island nations more important. High freight cost will reduce profit however restricted or no air freight space prevents profit.

Table 1. Overview of marine aquarium commodities commercially traded during the past decade within the Pacific Island nations.

Countries	Product						
	Finfish	Hard Corals	Soft Corals	Clams	Live Rock	Live Sand	Echinoder-mers
American Samoa	√	√		√	√		
Cook Islands	√			√			
FSM	√	√		√			
Fiji	√	√	√	√	√	√	√
Guam							
Kiribati	√			√			
Marshall Islands	√	√	√	√	√		
Niue							
Nauru							
CNMI							
New Caledonia	√			√			
Palau	√		√	√			√
PNG	√						
Pitcairn							
French Polynesia	√				√		

Product							
Countries	Finfish	Hard Corals	Soft Corals	Clams	Live Rock	Live Sand	Echinoder-mers
Samoa	✓	✓		✓	✓		
Solomon Islands	✓	✓	✓	✓			✓
Tokelau							
Tonga	✓	✓	✓	✓	✓		✓
Tuvalu							
Vanuatu	✓	✓	✓	✓	✓		✓
Wallis & Futuna							

9. PACIFIC REGION AQUACULTURE MARINE ORNAMENTAL COMMODITIES

Four major aquaculture commodities are cultured within the Pacific islands targeting the marine ornamental trade. These include; giant clams (*Tridacna sp.* and *Hippopus sp.*), a wide variety hard (Scleractinia) and soft (Alcyonacea) corals and live rock. Technology for the culture of these commodities is well documented and is relatively simple, however there are currently only a limited number of skilled technicians within the Pacific region with this knowledge. Improvements in regional skills and technology transfer through community based extension programmes throughout the region will greatly increase this knowledge base and provide the essential skills to develop an industry for these commodities. Several additional commodities are currently being investigated to determine if they can be cultured and in the long term be sold into this market (e.g. marine ornamental finfish). Niche markets for unique or specific organisms are a specialty of the marine ornamental industry, demanding high commodity returns and investigations into these products should be a priority for the region. One example is the sale of the black lip pearl oyster (*Pinctada margaritifera*) that has been implanted with round pearl nuclei. These products are sold as a specialty item indicating that with proper care the aquarist can cultivate their own black pearl.

This report focuses on the four commodities highlighted above. Through regional dialogue these commodities were targeted by the Pacific Island nations due to their ability to be cultured, market demand and the relatively high market prices that they fetch. It is anticipated that with advancements in knowledge of life histories, species biology, technology improvements and consumer acceptance of aquacultured products more species will be cultured for this market. A summary of Pacific Island nations' past and present public and commercial activities with cultured marine aquarium commodities is presented in Table 2.

Table 2. Country status of all aquaculture commodities cultured within the SPC Pacific island countries for commercial and Resource and Development (R & D) activities for the marine ornamental trade during the past decade.

Countries	Commodity					
	Giant	Hard Clam	Soft Corals	Live Corals	Marine Rock	Others Shrimps
American Samoa	✓					
Cook Islands	✓					Pearl Oysters
FSM	✓					Trochus
Fiji	✓	✓	✓	✓	✓	Trochus
Guam						
Kiribati	✓					
Marshall Islands	✓	✓	✓			Turbo
Niue						
Nauru						
CNMI	✓					

Commodity						
Countries	Giant	Hard Clam	Soft Corals	Live Corals	Marine Rock	Others Shrimps
New Caledonia	✓					
Palau	✓		✓			Trochus
PNG	✓					Trochus
Pitcairn						
French Polynesia	✓					Larval Finfish
Samoa	✓					
Solomon Islands	✓				✓	Trochus
Tokelau						
Tonga	✓					Trochus
Tuvalu	✓					
Vanuatu	✓	✓	✓			Trochus
Wallis & Futuna						

Giant clams have been artificially cultured in 14 Pacific Island nations, both in government and private sector hatchery facilities since the mid 1980's. Giant clams produced from government facilities have been utilised for restocking programmes to increase natural stocks populations and small scale community based farming programmes designed for both food consumption and in more recent times for sale into the marine ornamental industry. Production of giant clams from commercial facilities primarily target the marine ornamental market, however diversification in some facilities have targeted food and the shell trade.

Hard and soft corals are currently produced only in Fiji, RMI and Vanuatu for commercial purposes targeting the marine ornamental trade. However, most Pacific Island nations have undertaken small scale government and/or Non Government Organisation (NGO) resource and development projects focusing on the culture of hard corals and to a lesser degree soft coral for reef rehabilitation projects. Through regional dialogue and information gathered through this project there is much interest throughout the Pacific Island nations in developing hard and soft coral commodities for the marine ornamental trade. Therefore, information and technology transfer is required to assist the development of these commodities in many of these countries.

Fiji is the only country currently culturing live rock for the marine ornamental market, however nations with international airfreight access are collecting and exporting wild collected live rock.

Marine finfish and shrimps are currently being investigated in several nations to determine the biological and culture requirements of these commodities to determine if the production of these commodities is a viable biological and economic opportunity for the region. Section 10 provides a detailed account of each commodity's past and current status.

Through several regional initiatives (e.g. MAC) the promotion of aquaculture products for the marine ornamental trade as a substitute for wild harvested commodities in retailing nations (e.g. USA and Europe) has been the target of extensive public awareness campaigns and education. The continuation of these public awareness campaigns is essential to provide the information to allow consumers the understanding of sustainable aquaculture and increase the acceptance and marketability of these commodities. Aquacultured commodities must be competitive with wild collected specimens to obtain a share of the market. Therefore, aquaculture producers face numerous constraints, most notably producing a product of comparable quality (preferably better) and at competitive prices to those commodities collected directly from the wild. In general, cultured products are labour intensive, have higher risk factors and incur time delays in profit earnings when compared to the wild collection of similar products. Aquaculture, irrespective of which market is targeted, is a business and therefore must operate as a business enterprise utilising business plans and management systems, ultimately relying on positive cash flows. The marine aquarium industry is a complex business relying on a chain of custody, requiring considerable capital outlay and business skills and is subjected to international market conditions that constantly change. All these essential attributes must be assessed and evaluated when considering entering this industry.

Parks, et al. (2003) reported that even through the culture of marine ornamental products (e.g. live corals and live rock) are perceived to be able to off set the initial economic burden of discontinuing wild harvesting, recent research has shown these practices are not encouraging for regional entrepreneurs, resource managers and decision makers seeking sustainability relief through culture promotion. These perceptions are attributed to high startup cost requirements, variable operating costs, and the comparably low return base on the product pricing structures require to remain competitive against wild caught product.

The majority of aquacultured products currently produced within the Pacific destined for the marine ornamental industry are regulated by the Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES). These include all giant clams and most hard corals. Therefore, in order to culture and trade in these commodities CITES regulations and requirements must be met. A summary of these regulations is provided below.

9.1 CITES

In 1973, the international community adopted CITES, which is an international agreement to regulate international trade (import, export and re-export) of wildlife species listed (FAO, 2003a). The aim is to protect wildlife by ensuring trade does not threaten the survival of a species in the wild, prevent further decline in wildlife populations, and ensure that international trade is based on sustainable use (Bruckner, 2001).

CITES provides for three levels of trade control depending on the conservation status of the species, and each level of protection has different permit requirements. (Forum Secretariat, 1999, Bruckner, 2001 & FAO, 2003a). The provisions of all annexes apply to species of fauna and flora, whether dead or alive, and also parts or products derived from these species (e.g. shell of a giant clam) (FAO, 2003a). These are:

- Appendix I:** Identifies immediately endangered species and all international trade in these species is totally prohibited.
- Appendix II:** Lists species that risk becoming endangered within a short period of time. International trade for these species is strictly regulated through licenses or permits.
- Appendix III:** Lists species that are endangered on the territory of one or more countries and are regulated by specific measures that aim to prevent or reduce their exploitation.

There are several hundred species listed in Appendix I and over 20,000 species listed on Appendix II (FAO, 2003a). Table 3 provides a list of CITES registered invertebrates organisms relevant to the marine ornamental trade.

Table 3. A list of CITES invertebrates relevant to the marine ornamental trade within the Pacific (adopted from FAO, 2003a).

SPECIES	CITES APPENDIX
Giant Clams	
<i>Hippopus Hippous</i> , <i>H. porcellanus</i> .	II
<i>Tridacna gigas</i> , <i>T. derasa</i> , <i>T. maxima</i> , <i>T. squamosa</i> , <i>T. crocea</i> , <i>T. tevorooa</i>	II
Coral Like Animals	
Class Anthozoa	
Order Coenothecalia	II
Order Antipatharia	II
Order Stolonifera (<i>Tubiporidae sp.</i>)	II
Order Scleractinia	II
Class Hydrozoa	
Order Mileporina (<i>Mileporidae sp.</i> and <i>Milepora sp.</i>)	II
Order Stylasterina (<i>Stylasteridae sp.</i>)	II

Currently there is a large number of marine ornamental species, both cultured and wild collected that are traded within this industry that are registered in the Appendix II. These species can be traded commercially, but require an exporting permit from the host nation stating that trade in these species is legal and is not detrimental to the species survival. Each CITES member country is required under the convention to possess a scientific and management authority. The scientific authority is responsible for reviewing all export permits, undertake an assessment to determine if the shipment of commodities is a non-detriment finding and determine the volume of a species that can be sustainably traded. The management authority is responsible for issuing permits and certificates for trade (Bruckner, 2001). Fiji, Papua New Guinea (PNG) and Vanuatu are currently the only Pacific island countries that are signatories to CITES.

All aquacultured commodities of Appendix II organisms (refer Table 3) are termed "captive bred" and require this information clearly noted in all CITES export permits. Captive bred status infers that species have been raised in captivity, are removed from wild populations and do not require continued harvesting from wild population stocks to maintain broodstock (Bruckner, 2001). A CITES listed animal that is captive bred to the F2 generation level can be traded without a CITES export permit, provided the captive breeding facility is certified by CITES. Ongoing debate centred on the merits of the CITES requirement for all captive bred commodities to originate from at least F1 generation broodstock has been around for several years, much of which relates to coral fragmentation culture using wild sourced fragments.

10. AQUACULTURE COMMODITY ASSESSMENT

The section below provides a detailed description of the current aquaculture commodities cultured within the Pacific islands for sale to the international marine ornamental trade. These include; giant clam (*Tridacna* and *Hippopus*), hard (*Scleractinia*) and soft (*Alcyonacea*) coral, live rock, marine finfish and marine ornamental shrimp.

In all activities that are designed to assist the development of commercial fisheries products care should be exercised to assist the development on a sustainable basis and therefore marine stock assessments and appropriate management plans need to be developed simultaneously with developmental activities.

10.1 Giant Clam

There are eight extant species of giant clams, or tridacnids within two genera that occur within the Pacific islands. These include *Tridacna gigas*, *T. derasa*, *T. maxima*, *T. squamosa*, *T. crocea*, *T. tevoroa*, *Hippopus hippopus* and *H. porcellanus*. The past two decades has witnessed an enormous interest in the biology, ecology and life history data for all species of giant clams. This interest has further been increased since the realization in the early 1990's that all species can be artificially cultivated with relatively simple technology that is appropriate to the Pacific islands. There is currently a substantial body of published and unpublished scientific and "grey" literature on many aspects of the biology, ecology and life history of giant clams within the Pacific islands and the culture of all species of giant clams for commercial and subsistence purposes is well understood (Copland and Lucas, 1988, Heslinga et al., 1990, Braley, 1992, Calumpong, 1992 and Lindsay and Bell, 2000).

All species of giant clam share a unique symbiotic relationship with the microscopic dinoflagellate, *Symbiodinium microadriaticum*, also known as zooxanthellae (Copland and Lucas, 1988). The photosynthetic products derived from zooxanthellae are used directly by clams and many of the nutritional requirements of clams are met by this relationship (Dalzell et al., 1990). Hence, all species of giant clam do not need to be artificially fed, greatly reducing cost and labour requirements for their culture. The availability of light is therefore the most important environmental factor for determining clam growth and survival.

All giant clam species are protandrous simultaneous hermaphrodites, generally releasing male gametes before female gametes. Gamete release occurs through the excurrent siphon and in both natural and artificial conditions may stimulate other clams in close proximity to release gametes. Spawning periodicity in lower latitudes is continuous with a percentage of the population possessing ripe gametes all year round. The larval life cycle of giant clams is less than two weeks in duration near the equator and is well documented (Barley, 1992, Calumpong, 1992 and Lindsay and Bell, 2000).

In the past, large scale commercial fisheries targeting the adductor meat of giant clams (much of which was illegal) was undertaken by long range Taiwanese fishing vessels within the Pacific region, reaching a peak in the mid 1970's. Associated with this fishery, giant clams were harvested for their shells from many reefs within the Pacific and traded into the curios trade (Munro, 1993b). This exploitation of giant clam stocks led to greatly reduced stock populations within the region, especially for the two largest species *T. gigas* and *T. derasa* and prompted the registration of all giant clams as a threatened species with CITES. In more recent times, harvesting of clams for subsistence and commercial activities has further declined clam stock populations through out the region, especially on reefs close to urban population centers.

Tridacnids have been and are an important component of the diets of people of the Pacific. There are few locations within the Pacific where tridacnids are not gathered on a daily basis and found in local markets (Munro, 1993b). The extraction and collection of clams from reefs is extremely simple. In areas where clams are collected for subsistence food purposes the flesh is simply excised from the shell or the whole animal is collected (Munro, 1993b).

Almost without exception, each Pacific nation has been involved in giant clam stock assessments, restocking programmes and has explored the possibility and the potential for farming giant clams for subsistence and commercial gain. Fourteen Pacific island nations have operated government/institutional owned giant clams hatcheries over the past decade with several nations (e.g. FSM, RMI and Samoa) possessing more than one hatchery facility within the country. Three (RMI, Samoa and Kiribati) privately owned and operated giant clam hatcheries have been developed and produced product within the region. Each of these facilities has cultured the smaller bright coloured clam species (*T. maxima* and *T. squamosa*) for sale directly into the marine ornamental trade.

All species of giant clam can be cultivated through proven hatchery and reef growout technology for reseeded, subsistence and commercial use. The larger species (*T. gigas* and *T. derasa*) due to their faster growth rates have been targeted throughout the Pacific for reseeded and subsistence farming purposes. In addition, and to a much lesser degree these species have been commercially grown for their adductor muscle and shell. Much of this activity was undertaken during the mid 1980's and early 1990's. With the event of production technology clarified for the smaller species in the early 1990's (*T. maxima*, *T. crocea* and *T. squamosa*), the introduction of CITES regulations restricting trade in wild collected giant clams, and the increased demand for tropical species for the marine aquarium industry, the smaller brightly coloured clam species have been the focus of extensive development projects designed to cultured these species to be traded as a commercial commodity for the marine ornamental industry. The iridescent blue, green and combinations of these colours are sort by the marine ornamental industry, subsequently paying premium prices for high quality clams with these colours.

Translocations and introduction of many species of giant clams have occurred throughout the Pacific region over the past decade for the dual purpose of increasing local stock populations and to develop commercial activities. Table 4 provides a summary of giant clam farming activities within the Pacific region over the past decade.

Table 4. Provides a summary of giant clam farming activities within the Pacific Islands for the past decade.

Nation	Hatchery	Growout	Species Cultured	Reseeding	Marine Ornamental
American Samoa	✓	✓	Td, Tm, Ts, Hh.	✓	✓
Cook Islands	✓	✓	Tm, Ts.	✓	✓
FSM	✓	✓	Tg, Td, Tm, Ts, Hh,	✓	✓
Fiji	✓	✓	Tg, Td, Tm, Ts, Tt, Hh.	✓	✓
Guam					
Kiribati	✓	✓	Tm, Td	✓	✓
Marshall Islands	✓	✓	Tg, Td, Tm, Ts, Hh.	✓	✓
Niue					
Nauru					
CNMI		✓	Td	✓	
New Caledonia	✓	✓	Tm, Td, Hh	✓	
Palau	✓	✓	Tg, Td, Tm, Ts, Tc, Hh, Hp.	✓	✓
PNG	✓	✓	Td	✓	✓
Pitcairn					
French Polynesia	SpatCollection		Tm	✓	
Samoa	✓	✓	Td, Tm, Ts, Hh.	✓	✓
Solomon Islands	✓	✓	Tg, Td, Tm, Ts, Tc, Hh.	✓	✓
Tokelau					
Tonga	✓	✓	Tg, Td, Tm, Ts, Tt, Hh.	✓	✓
Tuvalu	✓	✓	Td, Ts	✓	
Vanuatu	✓	✓	Tm, Ts, Tc		✓
Wallis & Futuna					

Giant Clams: *Tridacna gigas* (Tg), *T. derasa* (Td), *T. maxima* (Tm), *T. squamosa* (Ts), *T. crocea* (Tc), *T. tevoroa* (Tt), and *Hippopus hippopus* (Hh) and *H. porcellanus* (Hp).

Although all giant clam species are listed as Appendix II under CITES and can be cultured, commercial trade in wild collected animals is ongoing throughout the region. The collection of these clams is for the marine ornamental trade. In most cases each nation regulates the number of clams allowed to be harvested for export and the location of collections sites. Without exception the trade in wild collected giant clams are fully endorsed by the host nation and are exported with correct documentation as outlined by CITES (refer section 9.1).

Vanuatu for four consecutive years allowed the wild collection of giant clam for export purposes to be undertaken without suitable management regulations limiting export numbers. This wild harvest culminated in the year 2000 with the wild harvest and export of 17,621 clams (11,394 *T. crocea*, 4,825 *T. maxima* and 1,402 *T. squamosa*) resulting in a dramatic decline in wild stock populations in areas fished and the intervention of the Fisheries Division, through legislation, prohibiting the export of all wild collected clams from the nation. Currently, few commercial and/or government giant clam facilities culture *T. crocea*, therefore cultured product at present cannot meet the demands of the marine ornamental trade for *T. crocea*. Until such time that production capacity from cultured commodities meets this demand, the need to harvest wild clams will remain.

Tonga, and to a lesser degree the Marshall Islands, dominate the trade in cultured giant clams with the regular sale of three species of clam, *T. derasa*, *T. maxima* and *T. squamosa* for the marine ornamental industry. Annual figures for the sale of clams from Tonga for four consecutive years are as presented in table 5.

Table 5. List of cultured giant clams sold into the marine ornamental industry in Tonga.

	1997	1998	1999	2000
<i>T. derasa</i>	2,739	4,586	2,140	4,275
<i>T. squamosa</i>	513	490	107	6,630
<i>T. maxima</i>	5,806	12,539	7,995	2,393
Total	9,058	17,615	10,242	13,298

The past decade has witnessed a steady increase in the demand for giant clam from the marine ornamental industry. Although all species are traded, the demand is by far the highest for the smaller brightly coloured species of *T. crocea* and *T. maxima*. Clam demand within this industry appears to have stabilised over the past several years with weekly demands fluctuating with seasonal consumer purchasing. Nevertheless, giant clams are a sought after item and remain a "must have" item in marine aquaria. Much of the supply of clams originate within the Pacific and have been obtained from wild harvests. Clam revenues vary considerably based on morphological (shape, size, mantle colour species), economical and consumer demands. The smaller species *T. crocea* and *T. maxima* are the most popular among consumers and maintain higher prices than the other species. Average prices per clam vary widely, however from stakeholder discussions a bright coloured 5 cm *T. maxima* would provide a farm gate price of between US\$6.00 and US\$10.00 and subsequently retailing in the order of US\$ 60-100 dollars. Correspondence with US based retail outlets, the demand for high quality brightly coloured mantle clams is high and the market has considerable scope to expand, however markets for dull coloured clams is limited with a distinct preference of consumers not to purchase.

In time, as more commercial producer's culture giant clams, especially the smaller higher priced aquarium species, it is anticipated that cultured products will replace wild collected commodities and thus provide an avenue to decrease wild harvesting. However, before this objective can be achieved several important initiatives need to be undertaken. These include;

- greatly increased production and hence greater availability of cultured clams,
- a much wider variety of species, sizes, and colour being offered to the trade,
- improvements in product quality (better than wild collected).
- economically competitive with wild collected clams, and
- improve regulative and enforcement initiatives within the member countries

The culture of giant clams is technically feasible and is an environmentally sound culture practice for the Pacific. Market acceptance of cultured giant clams within the marine ornamental trade is well established, however before the long term economical gains can be achieved cultured clams must be more competitive (size and colour) with wild harvest specimens.

It is therefore recommended that SPC continue to act as a facilitating agency collating and distributing information relevant to all aspects of giant clam farming with special consideration to assist the region to develop a marketing strategy targeting high market values for giant clam commodities. Further development of high valued species and associated colours and sizes needs to be addressed. Furthermore, SPC should consider assisting through information and technical transfer the development of community-based growout operations for local commodities. These farms would need to be developed in conjunction with the private sector hatcheries, wholesalers and exporters.

10.2 Live Coral

Corals have been collected from tropical reefs throughout the world and traded in the marine aquarium market as a live commodity or in the marine curio market as a dead (skeleton) commodity for many years. A wide variety of hard corals have been collected, dried and sold as marine curios. The curios business has been an ongoing concern in the Pacific islands for many decades and most nations have supplied commodities at some stage for this trade. The curios trade increased rapidly within the Pacific region during the 1970's and 1980's with Fiji, New Caledonia, Kiribati, Samoa, Solomon Islands and the Marshall Islands dominating the regions export (SPREP, 1994). In more recent times, the introduction of coral extraction laws and regulations have curtailed this business with some nations banning the collection of corals for this trade with others allowing harvesting under strict permit and regulation controls.

Live hard (order Scleractinia) and soft (order Alcyonaria) corals have been collected and traded in the marine ornamental industry. Coral commodities have increased ten-fold since 1985 with 90 per cent of the coral traded globally exported from eight Indo-Pacific nations with Indonesia and Fiji the two dominant suppliers, both in terms of volume and revenue exported (MAC pers. com.). Live coral is or has been exported from the majority of Pacific island nations at one time or another. Species found in the family Pocilloporidae, Fungiidae and Acroporidae are the top three hard corals traded (MAC, pers. com.). It is estimated that approximately 50 species of hard and soft corals are exported from the Pacific islands each year with estimated annual revenue of US\$5 million (MAC, pers. com., 2003).

Hard and soft coral possess two forms of reproduction, sexual and asexual. Sexual reproduction involves the release of sperm and eggs, which develop into a free-swimming larval form (planule). The planule settle, metamorphose and develop into primary polyps. Asexual reproduction occurs when corals produce fragments, buds or asexual planule, resulting in clonal progogules which are genetic replicates of the parent colony.

Artificial culture of corals through sexual reproduction has been achieved in research institutions for a limited number of species and requires the use of hatchery facilities and skilled technicians. The artificial culture of both hard and soft coral species using asexual reproduction has been achieved for a wide variety of species, requiring no land-based facilities and the use of minimal skills. Therefore, the culture of hard and soft corals through asexual reproduction, utilizing proven technology, is applicable to a wide range of farming applications within the Pacific Islands. Furthermore, most hard corals, due to their symbiotic relationship with microscopic algae (zooxanthellae), do not require feeding, greatly reducing labour and overall operational costs.

The culture of hard or soft corals is a simple procedure requiring the excise of either a piece of or the whole coral colony being removed from the substrate, usually using a hammer and chisel for hard corals and scissor or knife for soft corals. Once the specimen has been detached from the parent host or substrate, it can be removed and cultured. The excised pieces of coral are usually reattached (e.g. epoxy resin for hard corals and twine for soft corals) to an artificial substrate based on calcium carbonate and placed on underwater growout systems to allow the coral to recover from the excise and reattach to the artificial substrate provided. Most growout systems are located in shallow water in protected areas on reefs. The cuttings are cultured between 5-12 months depending on species and size required and exported through standard live marine aquarium protocols to markets. Corals can be cultured in land based facilities, however the cost of producing these products is considerably higher than being cultured on the reef and is not a prerequisite for their culture.

Most Pacific nations are currently culturing hard and/or soft corals. The production is small scale (less than 1500 pieces annually) and undertaken for applied research and/or aquaculture demonstration programmes designed for coral reef rehabilitation projects or community based commercial alternative income generation activities (AIG) targeting the marine ornamental industry. These AIG programmes in some countries have been developed in conjunction with private sector commercial companies specializing in the marine ornamental industry.

Private sector companies in Fiji and to a much lesser extent the Marshall Islands and Vanuatu are the only nations within the Pacific region currently culturing hard and soft corals at commercial scales for the marine ornamental trade. Private sector companies in Palau and the Solomon Islands were actively culturing corals in the 1990's but have recently ceased operations. The majority of these operations targeted hard corals as opposed to soft corals as they are simpler to culture and transport.

The largest commercial hard coral farm currently operating within the Pacific is located in Fiji, with an estimated 25,000 individual fragments 'frags' from 40 species of hard coral currently under cultivation (Walt Smith International pers. com.). Table 5 provides an example of coral "frags" cultured by this company (Walt Smith International).

Table 6. The table below shows the type of coral "frags" cultured by Walt Smith International (WSI, pers., com.).

Trade Name	Scientific Name
Exquisite Turquoise	<i>Acropora hyacinthus</i>
Blue Tip	<i>Acropora hyacinthus</i>
Stunning Baby	<i>Acropora hyacinthus</i>
Purple Tricolor	<i>Acropora cerealis</i>
Groovy Tricolor	<i>Acropora cerealis</i>
Lavender and Violet	<i>Acropora secale</i>
Cactus Shaped Light Rose	<i>Pocillopora eydouxi</i>
Fiji Cultured Pretty	<i>Acropora insignis</i>
Hypnotic Lavender and Violet	<i>Acropora globiceps</i>
Magneta and Violet	<i>Acropora rosaria</i>
Fiji Cultured Rare	<i>Acropora valida</i>
Iridescent Green	<i>Acropora polystoma</i>
Stunning Green	<i>Hydnophora grandis</i>
Yellow Acropora	<i>Acropora milepora</i>
Wonderful Aquamarine and Lime Green Branches	<i>Acropora microclados</i>
Lavender with Blue Tipped Acropora	<i>Acropora loripes</i>
Vibrant Green Tabletop	<i>Acropora hyacinthus</i>
Fiji Cultured Lovely	<i>Acropora microclados plus Acropora loripes</i>
Terrific Fluorescent	<i>Acropora samoensis</i>

The demand for a wide range of hard and soft corals for the marine ornamental industry has increased dramatically over the past decade, with industry indications predicting increasing demands. However, this current demand is for wild collected specimens and not cultured product.

Cultured corals are considered in direct economic competition with wild collected coral and currently, wild collected corals hold premium prices and are more attractive to the consumers than their cultured counterparts. Both wild collected and cultured corals are transported and sold into the ornamental market in the same fashion.

In time, as more commercial producer's culture hard and soft corals, it is anticipated that cultured products will at least compete or replace (for those that can be cultured) wild collected coral commodities and thus provide an avenue to develop a more sustainable fishery and industry. However, before this objective can be achieved several important initiatives need to be undertaken. These include:

- greatly increased production and hence greater availability of cultured corals,
- a much wider variety of species cultured and offered to the trade,

- improvements in product quality (better than wild collected),
- economically competitive with wild collected corals, and above all,
- gain the support of the end consumer to purchase aquacultured corals in preference to wild collected specimens.

The last point was raised by several commercial operators and is currently seen as an impediment to the development of a cultured coral industry. Increased consumer awareness of cultured corals, their increased ability to adapt and survive in aquariums as compared to wild collected specimens, the positive effect these activities have on coral reefs, local community developments and that these practices are sustainable is required to further develop the market for cultured corals.

The culture of hard and soft corals is technically feasible and is an environmentally sound culture practice for the Pacific. However, market acceptance of these products and therefore long term income generation security has yet to be proven and therefore caution is advised for potential farmers. It is therefore recommended that SPC collate this market information and develop appropriate programmes in conjunction with the commercial facilities that will promote and provide public awareness and education of cultured hard and soft corals. If this marketing programme does indeed stimulate an increase in the sale of cultured corals then at this stage SPC should consider undertaking regional information and training programmes to assist the development of this industry. Furthermore, it is suggested that SPC take a leading role in assisting the development of community based coral farming programmes in association with a reputable wholesaler and/or export company. Thus providing an opportunity for direct employment and economic opportunities for smaller rural coastal communities within the Pacific region.

10.3 Live Rock

Live rock is a term used to describe coral rubble/reef rock that is coated or permeated with living organic material, much of which is the bright coloured (pink, purple or orange) marine coralline algae (Forum Secretariat, 1999). Pacific live rock typically has at a minimum 80 percent coverage of coralline algae, comparatively light when compared to Florida live rock or cultured live rock, generally sold as branches or slabs, and individual pieces weigh between 3-10 kilograms. Live rock is extracted from the reef generally in regions close to areas of high energy (wave action). Live rock has a dual function in a marine aquarium, as a structural/decorative material for the "reef tank" and as a bioactive material for the recycling of nutrients and waste products within aquarium systems (Forum Secretariat, 1999).

The Pacific islands supply the majority of the world market for live rock and are considered by the northern American industry to be the best quality available. Ninety-five percent of all live rock collected in the Pacific is sent to the United States (MAC pers. com). Live rock is or has been exported from the majority of Pacific island nations at one time or another. However, the export of live rock is economically dependent on large volumes being shipped and therefore the industry is constrained by access to large airfreight space and regular market connections. Fiji is the region's largest supply of live rock with the Kingdom of Tonga the next largest exporter. Several Pacific nations (e.g. Palau, FSM) have banned the removal of live rock from their reefs for this purpose. It is estimated that over 14 million kilograms of live rock was exported from the Pacific between 1992 and 2000 and live rock exports from Fiji and Tonga alone have doubled each consecutive year from 1992-1997 (MAC pers. com.). The Fiji industry is expecting to export 650,000 metric tonnes of live rock for the year 2003.

The culture of live rock was pioneered in Florida (USA) as a result of the government banning the collection of wild live rock. Cultured live rock utilizes very simple technology and is certainly applicable to community-scale operations within the Pacific. It is manufactured by using a calcium carbonate substrate (reef rock, limestone) crushed, mixed with cement and molded into desirable shapes. The addition of colour food dyes are used to provide the artificial rock with colour resembling natural rock. Once this mixture is hard it is transported to the reef and left for extended periods of time (8-16 months) to allow the natural settlement of coralline algae and other organisms. It is then harvested and sold as live rock.

Fiji (one company only) is the only country that is currently culturing live rock within the Pacific. It is estimated that 50,000 pieces of cultured live rock (approximately 120 tonnes) are currently under cultivation (Walt Smith International, pers. com.). As with all aquacultured products, cultured live rock must be economically competitive and of similar or better quality as wild collected live rock to obtain a significant share of the market. Saturation of the US market of wild collected live rock exported from Fiji in the last five years has driven the US and international markets out of competition (Heslinga, 1999 cited in parks et al, 2003). Since 2000, the price of live rock in the US originating from Fiji has declined by 50% and what was a previously a lucrative US based live rock aquaculture industry has now proved uneconomical due to the abundance of high quality wild harvested rock.

Live rock can be cultured in all Pacific nations. It is technically feasible and an environmentally sound activity for the Pacific region. However, the three largest constraints currently impeding the development of this industry is direct competition with wild harvested product, the fact that cultured rock is currently heavier than wild collected rock and therefore returns are lower due to increased airfreight costs to deliver the product to market and the time required to grow out product before any returns can be made.

Research into methodologies that can be incorporated into the cultured rock process that can lighten the end product is required. Reducing the weight of cultured rock even by 10 percent relates to a large freight cost saving when considering the product is usually sold by the tonne. Assistance from SPC to initiate an applied research programme addressing this constraint is needed.

10.4 Marine Finfish

Numerous tropical marine finfish are collected and traded in the marine ornamental industry which is dominated by Indonesia and the Philippines. These industries have in the past relied on unsustainable collection practices (e.g. cyanide) and subsequent damage to reef habitats has been extensive. Recent educational and legislative measures have curtailed these practices.

The Pacific nations combined are the second largest export of marine finfish commodities, exporting approximately 19 percent of the annual United States marine finfish trade which represents approximately two million US dollars a year (MAC pers. com.). Fiji, Kiribati, Marshall Islands, Tonga, Cook Islands and Vanuatu are the largest Pacific exporters of marine finfish for the year 2002 with over 150 species of fin fish species traded (MAC pers. com.). The most popular species traded are the Labridae (wrasses), Chaetodontidae (butterfly fish), Pomacentridae (anemone fish and damsel fish), Pomacanthidae (angel fish) and Acanthuridae (surgeonfish).

Information gathered for this report indicates that there is no commercial aquaculture production of marine finfish within the Pacific region for the international marine ornamental trade. Technology and basic life history information on the culture of marine ornamental finfish species is sparse, and for the majority of species culture methods are unknown. The exception is the genus of anemone fish (*Amphiprion sp.*). The majority of species of this genus have been successfully cultured. Large production facilities exist in the Bahamas, Puerto Rico, Florida and Australia (FAO, 2003a). This commercial technology has yet to be transferred into the Pacific. Although several commercial companies and research organisations within the region (e.g. Marshall Islands and French Polynesia) indicated that they have experimented with the culture of several species of clown fish, this has yet to reach commercial scale.

Aquacultured finfish must be economically competitive with wild collected specimens to obtain a share of the market. Therefore fish producers face numerous problems. Most notably, they must produce a product of comparable quality (preferably better) and at a competitive price. Marine finfish hatchery facilities require considerable capital investment to construct and maintain the required infrastructures, and require skilled labour and frequent infusions of working capital to produce commodities. The lack of biological and technical knowledge to culture a variety of aquarium finfish species, and the ability to culture a product that is price competitive with wild caught alternatives, are major factors preventing the development of cultured finfish for the marine ornamental trade. Advances in these areas are required before an industry is likely to develop in the Pacific.

Nevertheless, the adoption of small scale hatchery (backyard) technology development and practices in Asia (e.g. Indonesia) may provide a model applicable for the Pacific. These facilities operate with low capital and operational costs due to low technology usage. However, they rely on larger hatchery facilities to supply larvae and/or juveniles. For this technology to be successful within the Pacific region the requirement of one or more large fish hatcheries will need to be operational to supply the quality and quantity of fish. This requirement may need to be filled by government agencies.

A recent initiative within the region to study the potential of collecting marine finfish larval stages directly from the natural environment and on-grow the caught individuals is currently being examined. Initial information confirms that individual larval specimens of a wide range of finfish and other invertebrate and vertebrate larvae can be successfully collected. Initial data collected from the Solomon Islands indicated that the majority of species collected are not high end value aquarium species and therefore additional experimental work is required to target species of higher value (Mrs. Hair pers. com). However, recent studies from French Polynesia provided more promising results with higher levels of commercially valuable fish larvae captured (Mr. Remoissenet pers. com.). Several collection methods have been trialed (e.g. light traps and crest nets) each has their own inherent problems capturing larvae and maintaining high larval survival. Varied mortality rates have been recorded with these capture methods, transportation to the land or water based facilities and keeping the fish alive as they grow. Nevertheless, these experimental programmes may provide an avenue to allow Pacific communities access to finfish larvae of commercially valuable marine aquarium finfish, on-grow them to commercial size at a competitive cost to those captured from the wild. Preliminary economic studies of these commodities undertaken in French Polynesia have indicated the markets acceptance of the fin fish and subsequent export values are consistent with wild collected commodities of the same species and size. The demand for these fish is assumed to be large with replacement of wild captured fish.

It is recommended that SPC continue to collate information pertaining to these scientific studies and distribute findings when available. If in time the assessment for the collection and culture of these finfish appears to be commercially viable then this technology should be transferred to the member nations. The development of nation based legislation to provide sustainable management protocols for this fishery should be consistent with the developed of this industry.

Additional information on the wild capture of marine finfish larval can be obtained from Cathy Hair (email: c.hair@cgiar.org), Mr. René Galzin (email: galzin@univ-perp.fr) and/or Vincent Dufour (email: Vincent.dufour@aqua-fish.com).

10.5 Marine Shrimp

The small colourful marine banded coral shrimp (*Stenopus sp*) is a high value marine commodity item that has been collected and exported from the majority of marine ornamental collectors in the Pacific and Indian oceans. More recently, scientific investigations of the biology and life history of these shrimps have been undertaken, resulting in the understanding of the animal's life cycle and the successful small scale artificial culture of these animals. Commercial production has yet to be attained. Nevertheless the research has indicated that these commercially valuable marine shrimp may be able to be artificially cultured at commercial numbers. Additional experimentation and scientific work is required to further define biological parameters and streamline the various growth stages and feeding requirements of these organisms. If the end results indicate suitable biological and economic parameters for commercialization it is recommended that SPC through the Aquaculture Program, assess, compile and distribute all relevant information to all member nations.

In addition, larval stages of these shrimp and marine crayfish are actively collected from the environment using the same techniques discussed above for marine finfish (refer section 10.4). Additional scientific research is required to increase collection numbers, increase larval metamorphosis survival and juvenile growth and survival. However, as with several of the high priced marine finfish discussed above this method has the potential to be an environmental and economic prospect for the Pacific region. As of now information is not available to undertake an economic analysis of this commodity for the marine ornamental trade.

11. ECONOMIC, FINANCIAL ASSESSMENT AND OPPORTUNITIES

The island countries of the Pacific have a lot in common, but also a diversity of characteristics and circumstances. They have benefited from a range of regional programmes that have achieved economies of scale in terms of sharing and spreading project overheads, while at the same time targeting the peculiar needs of each that underpin national goals and objectives based on local requirements. Nevertheless, specific regional development efforts on occasion will inevitably be applicable more to some than to others, project by project, given different inventories of natural resource endowments.

Economic opportunities are closely related to these resource endowments; and endowments are often associated with land and sea masses. This variability offers certain economic development opportunities. For example, atoll countries of the region, by definition, have extremely limited land resources, with characteristically poor soils and scarce fresh water resources. In some cases, however, some of these natural disadvantages are somewhat partly mitigated by opportunities and development challenges presented by maritime jurisdictions and entitlements. Table 7 provides an outline of the characteristic features of the Pacific island countries that demonstrate some of their shared makeup as well as highlight their vast physical differences.

Table 7. Geographic Outline of the Pacific Island Countries (adopted from SPC, 2003).

Country	Sea Area (‘000 km ²)	Land Area (km ²)	Population (total)	Pop. Density (per km ²)	Urban Pop. (%)
American Samoa	390	200	60,000	335	48
Cook Islands	1,830	237	17,900	97	59
FSM	2,780	701	110,700	162	27
Fiji	1,290	18,333	823,300	45	46
Guam	218	541	159,900	297	38
Kiribati	3,550	811	86,900	108	37
Marshall Islands	2,131	181	53,200	298	65
Nauru	320	21	11,900	578	100
Niue	390	259	1,882	7	32
Northern Mariana	777	471	73,300	172	90
New Caledonia	1,740	19,103	229,300	12	71
Palau	629	488	19,900	41	71
Papua New Guinea	3,120	462	5,471,200	12	15
Pitcairn	800	39	47	1	88
French Polynesia	5,030	3,521	239,800	69	54
Samoa	120	2,935	177,800	59	22
Solomon Islands	1,340	28,370	439,400	16	13
Tokelau	290	12	1,516	126	0
Tonga	700	649	101,100	135	36
Tuvalu	900	26	10,100	308	50
Vanuatu	680	12,190	199,600	17	50
Wallis and Futuna	300	255	14,700	58	0
Total	30,569	551,653	8,274,163	NA	NA

In addition to the above physical characteristics that play a major role in influencing economic development strategies Pacific island countries also face many other impediments and disadvantages to national development efforts. Typically, they suffer through remoteness from main export markets. Issues such as insularity, fragile ecosystems, lack of natural resources, high dependency on imports, high coast-to-land ratios, and for most, small physical and economic size, pose significant economic challenges.

Given these economic limitations, it is to be expected that countries of the region should explore the viability of all opportunities that their natural endowments may present. Evaluating the economic and financial potential for developing marine products for the export ornamental markets fits in with this entrepreneurial approach to identifying and exploiting limited economic opportunities. Indeed, some countries of the region have already experimented with this potential, and have had private sector investors undertake commercial operations, with varying results.

The four countries that have pursued the export of marine ornamental products, and had information available to the team, are listed in the following tables.

Table 8. Numbers and estimated values in US dollars of aquarium organisms exported from the Solomon Islands for the years 1996-1999.

Year	1996	1997	1998	1999
Aquarium (Live Rock)				
Pieces	84,935	3,606	58,188	80,039
Value (US\$)	28,730	1,406	22,632	31,163
Coral				
Pieces	175,203	2,467	84,755	58,181
Value (US\$)	76,385	37,696	26,471	27,532
Invertebrates				
Pieces	37,826	5,396	13,944	15,211
Value (US\$)	22,999	17,225	16,490	12,745
Total Value (US\$)	128,114	56,327	65,593	71,440

Table 9. Summary of marine ornamental commodities exported from Vanuatu in 2000.

Product	Quantity (Pieces)	Value (US\$)
Giant Clams	18,000	77,000
Live Rock	8 tonnes	8,000
Fin Fish	3,000	20,000

Table 10. Combined value of Marine Ornamental Commodities exported from Tonga for the year 1997-2000.

Year	1997	1998	1999	2000
US Dollars	445,694	485,403	794,729	1,520,230

Table 11. Summary of estimated numbers of aquarium organisms exported from Fiji (Fiji Government, 2003). (* values from January to August, 2003)

Year	1996	1997	1998	1999	2000	2001	2002	2003
Coral						262,710	80,000	64,662*
Fish	257,262	237,213	235,491	231,336	254,028			
Live Rock					107 mt	106 mt	134 mt	450* mt

The economic and financial viability of the operations cited were not investigated in the course of this study, due to sensitive commercial considerations. However, some have now been in operation for a number of years. The tables above also provide some indication of the potential that may exist in some countries of the region given their particular endowments. Most would have potentials to various degrees, and while the physical circumstances may exist and be conducive to productivity, in many situations other cost elements will dictate the financial viability of such operations.

The availability of transportation means, both air and sea will be crucial to such operations. The numbers above, in terms of pieces and volumes, give some indication of the capacities that exist and necessary for feasible operations. Good air connections, in particular, will be necessary for transporting live product such as ornamental finfish. For some countries, good internal transportation arrangements will also be essential to ensure the smooth transfer of product from capture and farm areas to export ports.

Although there are generic business principles common to all such operations, like all businesses there are also business considerations and characteristics that are unique to each type. Farming and harvesting marine ornamental animals, as the technical sections of this report demonstrate, will require for most operators in most countries appropriate training and transfer of skills. Likewise, harvesting, packaging, transportation, and marketing will all require specialised knowledge. Some of these skills may be obtained from general training and demonstration workshops. Others may be acquired through operators' own business backgrounds.

As a regional initiative, there will be mileage in providing some of these skills transfer through regional and sub-regional training programmes. This would apply especially to the technical and production aspects of operations, which must also include in its content adequate consideration for environmental concerns. Likewise, financial, marketing, costing and pricing, and other aspects of business operations must be in place for such ventures to survive. These, however, may be conveniently facilitated by business entrepreneurs when the potential of production units, say at the village and community levels, have been demonstrated.

The economics of producing and internationally marketing marine ornamentals will vary from country to country. While production yields will depend mostly on prevailing ecosystems, breaking even or achieving profit situations will depend on many extraneous factors such as freight costs and reasonable access to overseas markets. Production units, as well as marketing units, will need to take these peculiarities into account. In some situations it may be prudent to organise production on a national basis while that of marketing on a regional or sub-regional one, involving a cartel of producers in more than one country. However, sufficient lessons from experience demonstrate that the profit motive that drives the private sector is an important ingredient for commercial success.

Export markets for marine ornamentals, as illustrated in the introductory sections of the report above, are huge, and the ability of Pacific island countries to penetrate these markets and achieve profitable operations will provide one more opportunity for cash income generation. Some countries of the region have already demonstrated the technical and financial feasibility of the business. Others have also given examples of how difficult it can be at times to develop a business idea into a viable operation, as is common in most areas of commerce. The best approach is to know as much as possible about the business beforehand. This can be satisfied in large part through technical training and appropriate market and business management studies, which can be facilitated through a regional initiative.

Assuming that the technical and production feasibility of the various marine ornamental animals have been researched and demonstrated, a number of "business" models could be considered for different localities depending on geographical logistics, transportation facilities, and property rights. For example, most countries of the region have extensive experience with inshore and offshore fisheries activities undertaken by locals. For many, the experience from community-based property rights and village council management regimes may be emulated in a community-based development and management of aquaculture production units. Also, the experience from other export sectors and industries show that only a few dedicated specialist export business operators may be able to adequately cater for the export marketing needs of numerous producers.

As inferred above, like most regional initiatives, they tend by nature to have varying application to various recipient constituencies. Some countries of the region are better endowed in terms of natural resources and basic infrastructure than others. That range and volume of resources, and related range of development opportunities, will invariably dictate the degree of priority and intensity placed on any development initiative by each nation. In the case of most countries, however, a well-planned sustainable approach to farming, harvesting and exporting marine ornamental products provide one more avenue for economic development and income generation from among an acutely limited range of opportunities.

11.1 Markets for Marine Ornamental Aquaculture Commodities

The marine aquarium industry is a hobby that is confined and practiced mainly by industrialised nations. The three largest importers of wild collected and cultured marine and freshwater ornamental commodities, accepting approximately 77% of all trade are in descending order, the United States of America, Europe (Germany, France and United Kingdom) and Japan (FAO, 2003a).

The largest market for Pacific island marine aquarium commodities, both wild collected and cultured is the US and therefore current operations within the Pacific region are developed to target and cater for this market. Access to this market is dictated by flight availability and travel time en-route. The majority of cultured giant clams, and hard and soft corals are directly shipped to this market whilst all cultured live rock is sent to the US. Fiji and to a much lesser degree by volume, the Marshall Islands and Samoa act as transshipping locations for marine aquarium products originating from neighbouring countries which do not have access to direct airline services to the US. In some cases, airline services are available in these nations, however limitations on freight space, the uncertainty of shipment availability and shipping cost prevent these operations from developing a consistent supply of product to market. Subsequently, Fiji is currently the largest export of marine aquarium products within the Pacific with cultured commodities contributing a small percent of the overall product exported.

Some marine commodities are exported directly to European countries from Fiji, however much of the Pacific product destined for European markets are first shipped to Los Angeles, the center for the US importation of aquarium commodities and then subsequently transshipped directly or held in recovery operations (2-4 days) and then sent onto these markets. Direct travel time to these destinations exceeds industry standards and therefore mortality rates are greatly increased.

Different commodities have maximum time periods in which they can survive during transit, after which mortality rates are unacceptable. These different transit times play an important role in dictating freight routes for the various products. Unfortunately, in most shipments of marine aquarium commodities, irrespective whether the products are wild collected or cultured, mortality occurs. Improved techniques in animal husbandry, commodity health, water quality parameters, shipping, handling and packaging methods have greatly decreased mortality rates over the past decade and it is anticipated that further improvements are expected within the industry which will further improve survival rates. The shortest period of time in transit for all marine aquarium products is desirable.

Cultured giant clams can be shipped up to 30 hours before unacceptable mortality occurs, however large specimens are more susceptible to mortality and therefore are usually shipped with transit times of less than 24 hours. Similarly, hard corals can survive transit periods of up to 30 hours with most shippers preferring periods of less than 24 hours to maximize survival rates. Soft corals, due to their morphology and presence of "stinging" tentacles are difficult to ship and are shipped with travel times that do not exceed 24 hours. Live rock can be in transit up to 2-3 days.

The development of regional protocols and international acceptance of national permitting laws and regulation, especially those associated with CITES registered commodities will allow the distribution of aquacultured products to be increased. Government quarantine, environmental regulation and inspection requirements are currently impeding the transportation process of some products to market.

12. MARINE ORNAMENTAL AQUACULTURE COMMODITY DEVELOPMENTS, CONCERNS AND CONSTRAINTS

This section has been developed through stakeholder discussions with Governments, NGO's, communities and private sector companies to highlight potential issues that need to be addressed whilst developing a marine ornamental industry for aquaculture commodities. It is by no means an exhaustive or definitive list; however these issues were identified by the stakeholders as major points that must be assessed, both regionally and within each nation before a large scale industry is likely to be developed.

Marine aquaculture products developed for and traded in the marine ornamental industry from the Pacific islands is in its infancy and currently maintains a very small market share compared to wild collected marine commodities originating from the region. Nevertheless, the further development of existing and new aquaculture commodities destined for the international marine ornamental industry is considered a viable economic prospect for the Pacific Island region. The currently traded aquacultured commodities, giant clams, hard and soft corals and live rock have established markets, albeit small, within this industry and it is envisaged that as quantity and quality of these products develop, market share, market acceptance and commodity prices will increase.

The introduction of new cultured commodities within the region will further assist in the development and diversification of this industry which will in turn provide increased income opportunities for the region. Unfortunately, the current technology to cultivate marine species for this trade is restricted to a small number of animals and therefore will require scientific research into the life histories and culture practices of new commodities before the list of species increases. The development of these new species requires capital investment, time and should be pioneered by regional research and educational organizations, with all resulting information readily available and circulated to island nations.

The culture of micro and macro algal products to be utilised within the industry as a feed source and nutrient additive for the "reef tank" has been identified by the commercial sector as an area to be evaluated. An assessment through a research and development programme for the Pacific region for these commodities should be considered.

Due to the high biological diversity of the marine environments and species within the Pacific region and the current demand for wild collected marine commodities, each nation has the biological and environmental attributes suitable to develop aquaculture enterprises for the marine ornamental trade for those species currently cultured. However, constraints due to human resources, technology, infrastructure and access to reliable air transportation services currently impede the development of these commodities in this industry in the majority of Pacific Island nations.

Human resource and technological constraints for species cultured can be solved through appropriate capacity building and training programmes whilst infrastructural developments can be solved through appropriate development assistance and private sector involvement. Unfortunately, changes to airline service transportation links to international market destinations are driven by the aircraft service industry based on supply and demand for passenger travel requirements within the region. Recently, a study commissioned by the Pacific Islands Forum Secretariat addressing exporters concerns of limited airfreight access and capacity has indicated that the regional airlines need to improve and increase airfreight capacity to allow the further development of export of goods from the region. The Association of South Pacific Airlines has acknowledged these concerns and is considering the development of services to cater for the requirements of the export sectors. Improvements in these services will have a direct positive impact on the development of the marine ornamental market, both for cultured and wild collected commodities.

For those nations that currently do not have access to air service links directly to marine ornamental markets (US or Europe), or to regional centers where commodities can be transshipped and sent to market, they may consider suspending development programmes for this industry till such time as commodities can be delivered to markets. In addition, those nations that do have air service links, but have restrictions on freight space, distance traveled are inconsistent with the shipment of live commodities, have regionally high freight costs or have unreliable air freight services will need to carefully evaluate the potential economic benefits before an industry is to be developed. The essential attribute to this industry is having a reliable and cost efficiency mechanism to regularly airfreight commodities to international markets without which the potential to develop a sustainable long term operation is doubtful. The larger Pacific nations which have these air service link connections will remain the focal distribution points for these commodities.

Furthermore, market competition between marine aquarium products that can be cultured and those specimens collected from the wild must be addressed on a regional and international level. Increased public awareness campaigns and educational initiatives in consumer countries need to be further developed to provide direct positive information to the consumer on why they should purchase a product that is cultured as opposed to similar wild collected commodities. For those species that can be cultured this is an essential component to the development of the industry. The development of more species cultured, and improvements in quality and quantity of cultured commodities, will greatly assist in this endeavor. It is recommended that SPC on behalf of the region assist in the development of these issues. Partnership programs with agencies (e.g. Forum Secretariat), NGO's (e.g. Marine Aquarium Council) and the private sector should be investigated and developed accordingly.

Regional and national linkages between existing marine aquarium operators, export facilities and aquaculture operators producing commodities for the marine ornamental trade need to be further developed to allow commodities to access markets and be competitive. In most cases, large marine aquarium importers' preference is to purchase a wide range of marine commodities from individual supplies. Therefore an aquaculture producer supplying one or two commodities, irrespective of quality and quantity is at a disadvantage when marketing products. Hence, the development of aquaculture cooperatives or associations should be considered to assist the aquaculturist to culture and market their commodities. These linkages among farmers should improve information exchange, quality and quantity of product and marketing opportunities. It is therefore recommended that SPC include the development of these linkages and the development of cooperatives, both at national and regional levels into their work programme.

Regional cooperation between governments allowing cultured marine commodities to be transferred between island states to access air service links is required to facilitate the development of this industry. Regional agreements on quarantine procedures, CITES requirements and national environmental regulations will need to be harmonized within the region for this purpose. It is recommended that SPC undertake the lead role in facilitating and providing assistance to its member nations to develop regional protocols and procedures to allow the movement of commodities within the region.

If the above-mentioned assessments indicate the potential to cultivate and market aquaculture commodities, and there is a genuine interest in undertaking these activities within the community, it is recommended that each nation initiate development and supporting programmes for the promotion of this industry. It is therefore essential that for this industry to further develop, national governments and regional agencies, such as SPC, place the development of these activities as a priority and implement programmes accordingly.

The successful long term development of cultured commodities for this industry will require a regional approach that can provide assistance and technology transfer on a wide range of human resource and technical skill. These include:

- Human resource skill development,
- Biological and technical aquaculture assistance,
- Infrastructure development,
- Marketing and business skill development, and
- Policy and management plan development and enforcement.

Furthermore, an integrated approach including bilateral and multi-lateral donor organizations, regional agencies, national governments, NGOs and the private sector will be required to successfully develop this industry. The exact requirements of each nation will vary depending on current activities in place.

The development of an industry based on the culture of marine commodities for the marine ornamental trade must be based on sound business principals using business plans, projected capital investment, cash flows and above all, profit expectations. This is essential for any project to attain economic success. If these business projections indicate potential profits then the project should be considered for development. It is therefore recommended that regional agencies including SPC provide business training programmes to potential communities, companies and individuals to assist in the correct development of the industry.

The distribution network "chain of custody" for ornamental trade is a complex system. The chain of custody that is expected to be undertaken for culture commodities destined for this market is as follows:

- Commodity breeders (aquaculturist),
- Wholesalers,
- Exporters,
- Importers,
- Transhippers (distributors), and
- Retail outlets.

Each component will be required to be developed if this industry is to be successful. The first three chain of custody components mentioned above are undertaken within the Pacific region and therefore need to be developed in each nation. Assistance in each category will be required to expedite and develop a sustainable industry. Currently, the Aquaculture unit at SPC has been designed to act as the focal point for assistance for these activities and has been mandated through regional stakeholder meetings to provide these services. The current services provided by the team's two full time staff, allocation of funds to contract technical assistance and collaboration with the Council of Regional Organisations in the Pacific (CROP) and research organizations provide a sound basis for these objectives to be met. It is apparent, however, that additional resources are required to provide hands-on technical assistance in each of the nations, most likely through an extension programme, to assist and develop the human resource technical and business skills necessary to develop and expand this industry.

The marine aquarium industry is currently redeveloping itself to remove past unsustainable collection practices that have damaged (e.g. cyanide usage) and been detrimental to the marine environment, and to promote itself as a long term sustainable industry based on sound environmental practices. The culture of commodities destined for this market is environmentally sound and with due

diligence environmental damage and resource degradation is almost non-existent. Therefore, cultured commodities provide an avenue for some marine aquarium products to be assigned environmental labeling and reduce the perceived and actual environmental concerns relating to this industry.

Pacific regional and national initiatives need to be further developed to promote sustainable practices within this industry. It is recommended that SPC take the lead role and develop protocol standards and requirements (Eco-labeling) for aquacultured products destined for the marine ornamental industry resulting in a certification programme that is internationally accepted. This protocol should be developed along side similar programmes currently being developed for the wild collection of commodities for this industry (e.g. Marine Aquarium Council). Giant clams and hard corals which are internationally regulated by CITES may require additional protocols to be developed to conform to these regulations.

Through stakeholder discussions several issues were raised with regards to CITES restrictions on the production of commodities. The CITES requirement that all giant clams must be produced from F1 generation stocks before CITES requirements are negated is accepted and most facilities are producing F2 generation stocks. However, stakeholder consensus indicated that the regular inclusion of additional wild stock broodstock clams is a necessity so that hatchery operations can continue to maintain and increase genetic integrity of their stocks. This is of special concern for those hatchery operations which provide clams to reef reseeded programmes and commercial markets. Similarly, producers of hard and soft corals indicated that the addition of wild collected broodstock is a necessity to provide additional sources of cuttings material to maintain genetic integrity and product quality. These issues and concerns should be included in the SPC plan of work.

Concerns were raised over ownership, protection of genetic resources and intellectual property rights of nations and community owners of these resources. Much of which related to genetic resources originating from the Pacific being exported to foreign nations and subsequently cultured (e.g. hard and soft corals) and sold with the originating nation losing valuable income opportunities and ownership of these resources. These concerns and issues need to be discussed and appropriate regional and national responses developed.

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14. APPENDICES

14.1 Appendix 1: Terms of Reference (TOR)

The aim of this consultancy is to provide a regional assessment of the commercial viability for marine ornamental (giant clams, hard and soft corals, fish, live rock and shrimp) aquaculture to supply the export demand of the marine ornamental markets within the member countries of SPC.

The TOR will produce the following outputs:

1. Background Report

This will provide an overview of all SPC Pacific Island nations currently involved in the marine ornamental industry. This overview includes the following information:

- Introduction to the nation,
- Geography of the nation (freshwater, estuarine and marine),
- Past and current marine ornamental culture activities,
- Aquaculture and Environmental Legislation,
- List of companies culturing marine ornamentals, and
- List of supporting agencies.

2. Status Review and Evaluation Report

This will provide information pertaining to:

- The status of marine ornamental culture within the Pacific,
- The marketing demands for the various products,
- The concerns and constraints of these industries,
- An assessment and evaluation of the financial analysis of the industries for each nation visited,
- A detailed evaluation of each species assessed, using one Pacific island nation as an example for an evaluation on the cost-profit comparisons of extensive and intensive culture systems, and
- An assessment of the potential economic future trends of these industries.

14.2 Appendix 2: Background Reports

The section below provides an overview of aquaculture commodities associated with the international marine ornamental industry in all SPC member Pacific Island nations. The information presented is a combination of the consultant team's knowledge, literature review and in country discussions. The recent national aquaculture profiles undertaken for each Pacific nation has provided substantial information.

Seven countries were identified as leading nations in this field and were visited by the consultant team. This included; Federated States of Micronesia, Marshall Islands, Palau, Fiji, Samoa, Tonga and Vanuatu. Information document for each nation includes;

- Introduction to the nation.
- Geography of the nation.
- Past and current marine ornamental culture activities.
- Aquaculture and Environmental Legislation.
- List of companies culturing marine ornamentals.
- List of supporting agencies.

In addition, brief background information (sourced from communications and published literature) has been documented for the following nations; American Samoa, Cook Islands, Kiribati, Papua New Guinea, Solomon Islands, Tuvalu. Each nation is discussed separately.

The island nations of the Commonwealth of the Northern Marianas, Guam, Nauru, Niue, Tokelau, Pitcairn, Wallis and Futuna have not been included as each nation has no history in culturing aquaculture products for the marine ornamental trade. Furthermore, information was not obtainable during the time frame of the study for French Polynesia and New Caledonia and therefore these two nations have not been discussed.

14.2.1 Federated States of Micronesia

Introduction:

The Federated States of Micronesia (FSM) is a young independent nation. It was a United Nations Trust Territory administered by the United States of America until the two nations signed a Compact of Free Association in 1986 leading to the trusteeship termination in the same year. The Compact treaty established a special relationship with United States of America (USA) providing economic assistance. The funding provisions under the original compact have been recently renegotiated between the two countries to extend this relationship (August, 2003). The economic stability of the FSM presently relies heavily on financial assistance available through the compact, with US aid amounting to some 70 percent of the government's revenues. The FSM became a member of the United Nations (UN) in 1991 (Lindsay, 2002a & b).

The FSM is the largest and most diverse part of the greater Micronesian region comprising of four States which are, in geographic sequence from west to east, Yap, Chuuk, Pohnpei and Kosrae. All but Kosrae state consists of more than one island, and each State has considerable autonomy within the Federation.

The indigenous population is Micronesian with most of the people residing on the main islands of the state capitals. The FSM has a regionally high population birth rate and a census count in 2002 indicated the population within the nation was 110,700 (SPC, 2003), of which half are younger than 20 years of age. The past decade has witnessed internal migration from the outer lying islands to the state capitals and an ever increasing outward emigration of the citizen to Guam, Hawaii and the United States mainland in search of improved employment and education opportunities (Lindsay, 2002a & b).

Traditional, social and cultural institutions are very strong. Micronesian society is based on the extended family, which is responsible for the family welfare, especially in relation to customary family land. Ownership of land and marine areas varies between States. In Kosrae and Pohnpei, land is both privately and State owned, while marine areas are managed by the State as public trusts. In Chuuk and Yap, the majority of land and marine areas are privately owned or managed by individual estates. Land and in some States water, is acquired through inheritance, gift or, recently, by purchase. In all States, land cannot be sold to non-citizens of the FSM. These land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation (Lindsay, 2002c).

The nearest neighbors are New Guinea, Solomon Islands and Nauru to the south, Republic of Palau to the west, Guam and the Northern Mariana Islands to the north and the Republic of the Marshall Islands in the east.

Geography:

The total landmass of the FSM is 701 square kilometres, with a declared Exclusive Economic Zone (EEZ) covering over 2.78 million square kilometers. The FSM is comprised of 607 islands (atolls and high volcanic islands) between 1.0-9.9° N and 138.2-162.6° E with land elevation ranging from sea level to 791 metres (Lindsay, 2002b & c). The northeast trade wind belt heavily influences the tropical climate of the FSM with strong trade winds prevailing from December through April and periods of weaker winds and doldrums occurring from May to November. Rainfall is extremely high on the high volcanic islands of Kosrae, Pohnpei and Chuuk and can exceed 1,016 centimetres a year. The region is affected by storms and typhoons that are generally more severe in the western islands and by periods of drought and excessive rainfall associated with the "El Nino" (ENSO) phenomena (Lindsay, 2002b & c).

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found within the FSM, including barriers reefs, fringing reefs, atolls, large lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are well developed especially along the fringes of the high islands. The annual range of surface water temperatures is 27–30°C and the tidal range is about 1 m (Lindsay & Edward, 2000). The diversity of marine habitats within the nation provides a wide range of locations that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction (Lindsay & Edward 2000, FSM Government, 2000b and Lindsay, 2002b & c). Coastal degradation due to poor land use management practices and pollution is a growing concern for the nation. (Lindsay, 2002b & c).

Economy:

The economy of FSM is small and is largely dependent on aid provided through the Compact of Free Association with America. The US dollar is the currency used by the nation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, wholesale, retail and government services. The government services dominate the economy, with the FSM public sector maintaining wages almost double those of the private sector (FSM Government, 2000a). Minimal wage does vary between States, however the official minimal wage for Pohnpei State for the private sector is US\$1.35 per hour whilst US\$2.00 an hour is the official government wage.

Agriculture, fisheries, and tourism sectors are recognized as providing the long-term growth potential and comparative advantage of the FSM. The commercial tuna fishery (international and domestic) is the nation's second highest revenue earner with annual revenues between US ten to fifteen million dollars. (FSM Government, 1999a). Fifty thousand visitors (FSM Immigration) entered the FSM in 2000, with 17,000 individuals entering the nation as tourists, contributing small revenue earnings to the economy of the country (Lindsay, 2002b). Aquaculture contribution to the Gross Domestic Product (GDP) of the nation is negligible. The National and State governments consider the major economic challenge facing the FSM is to assist in building and developing an environment conducive to private sector growth (FSM Government, 2000a & b).

Legislative Issues:

The national constitution of the FSM, adopted in 1979 and amended in 1991, is the basis for legal authority and decision making for the nation. The legislation and institutional framework of the FSM includes, both National and individual State constitutions with each of the four States functioning as semi-autonomous governments. This structure makes it a prerogative of each State to enact their own legislation in line with their powers as mentioned in the FSM Constitution to address the concerns and issues of managing their own natural resources and sustainable development (Mace, 1999).

Title 24 of the code of the FSM (Marine Resource Act) provides the laws and regulations to manage and protect the environment. The responsibility of the majority of the codes within this law, have been essentially transferred to the State governments. Therefore, the majority of environmental management, wild capture fisheries and aquaculture related laws and regulations are the responsibility of the States and rest with the government agencies of Environmental Protection Agencies and Marine Resource Divisions. In all cases, these regulations are under developed as new issues arise. Each State has made efforts to control development and manage natural resources through the creation of land use plans, coastal zone plans, legislation and regulations (Mace, 1999). Specific laws have been designed to regulate aquaculture development are currently being considered for each State (Lindsay, 2002a, b & c).

The FSM is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Aquaculture:

Aquaculture has been the focus of technical development attention in the FSM for well over a decade with each state undertaking numerous aquaculture programmes. These programmes have been designed to provide a means of economic development for the nation through increased local employment opportunities in the private sector and increased natural stocks of certain species through nationwide restocking projects. The vast majority of past and current aquaculture programmes for the nation have been developed and undertaken through funding support programs from a wide range of regional and international donor agencies and managed through both government and educational institutions. Private sector aquaculture developed during this time period has been limited with neither long-term economic sustainability nor profitability in this sector (Lindsay, 2002a).

Nevertheless aquaculture has been highlighted by the National and State governments as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increasing natural resource stock populations through enhancement programs, and increasing economic exports for the nation (FSM Government 2000b).

The National and State government acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that policies are in place to allow and promote an aquaculture industry and to provide a legal mechanism to effectively regulate the industry if and when it develops (FSM Government, 1999b). Much debate still centers on the actual physical and monetary involvement the respective government should invest to develop a viable industry that does produce economic returns and creates long-term employment. Three broad aquaculture categories have been clearly acknowledged within the nation, these include (Lindsay, 2002a);

- Subsistence.
- Commercial.
- Restocking – Reseeding.

The FSM has diverse marine ecosystems that provide a range of suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the culture of marine ornamental organisms for the aquarium trade has been very limited in all States of the nation, with almost all of the programmes initiated since the mid 1990's. All most exclusively, all marine ornamental programmes that have been undertaken within the nation in the past have been designed and implemented by the government and educational institutions (public sector) through external funding assistance from a variety of sources. These programmes have been based on technology transfer and have provided international expertise to develop land and water based infrastructures (e.g. hatcheries and grow out farms), technical information transfer, training and advice primarily to government employees and the opportunity to participate in regional information exchange programmes and attend workshops and conferences (Lindsay, 2002a).

The majority of these activities have been based on known technology developed outside the region that has been adopted and altered through applied research and extension to suit the specific environmental and social requirements of the nation. The targeted organisms for this trade are giant clams and hard and soft corals.

Private sector involvement in culturing organisms for the marine ornamental trade presently and in the past has been minimal within the nation. Annual aquaculture seed production figures and economic values are almost non-existent for all organisms cultured for the marine ornamental trade (Lindsay, 2002a).

Giant Clams:

Giant clams have been artificially cultured within the FSM since 1991. The original and primary objective for the culture of these organisms was to restock depleted wild populations through a nation wide training and extension programme coordinated by National and State governments. From this initial objective a secondary objective was developed (mid 1990's) to develop community based commercial clam farming to supply clam meat to local and regional (Guam) markets. This secondary objective was further developed in the late 1990's to culture species to be commercial cultured for the marine ornamental trade (Lindsay, 2002a).

The FSM has four endemic species of giant clams (*Hippopus hippopus*, *Tridacna maxima*, *T. squamosa*, and *T. gigas*) and one introduced species *T. derasa* which was originally imported from Palau. Stock populations of all endemic species have been reduced considerably over the past two decades and it is believed that *T. gigas* may be locally extinct (Lindsay, 2002a).

There are two government owned and operated giant clams hatcheries within the nation. The National Aquaculture Center (NAC) based in Kosrae and the Pohnpei State government giant clam hatchery. Both hatcheries have produced numerous batches of giant clams of several species, most of which have been used for reef restocking programmes. The Kosrae facility is the larger of the two facilities and has produced considerably more clams. Both facilities have cultured *T. maxima* specifically for sale into the marine ornamental industry and have undertaken small scale test marketing of these products. The Pohnpei facility has in the recent past, supplied (given and sold) one marine aquarium company in Pohnpei with small colourful juvenile *T. maxima*. These clams have been either sold directly or on grown to larger sizes before sold into the marine aquarium market. The annual number of clams provided has been less than 3000 individuals (Lindsay, 2002a).

In addition, the Pohnpei Agriculture Training School (PATS) which provides vocational training courses in aquaculture operates a small marine hatchery that has produced several small batches of giant clams for hatchery and nursery training and small scale applied research purposes.

Private sector involvement in culturing giant clams has been limited to one aquarium collector-company in Pohnpei, which has purchased small numbers of clams from the Pohnpei hatchery in the past. Several commercial companies have shown interest in developing this industry, but to date, none have commenced operations.

Hard and Soft Corals:

There is no commercial cultivation of soft or hard corals within the nation for sale into the international marine ornamental industry. Pohnpei State, and to a lesser degree Kosrae State, have undertaken small scale government/donor agency sponsored hard and soft coral culture projects. These have included information transfer and hands on training workshops. In addition, there have been several small research projects undertaken within the nation that have provided direct positive evidence that these commodities can be cultured. These activities to date have not stimulated the development of an industry.

In the past, hard corals have been collected from each State, dried and exported into the international marine curio trade.

Live Rock:

There has been no trade in this commodity within the nation. The collection and subsequent sale of live rock is banned within the nation.

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past decade several small scale marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture.

Marine Shrimp:

There has been no trade in this commodity within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited trained technical and extension staff,
- Limited artificial seed production,
- Limited training facilities,
- Lack of legislative systems conducive to coastal and marine leasing arrangements,
- Limited National and State budgets,
- Very limited interest or motivation in coastal communities to undertake new ventures,
- Very limited private sector interest in commercial aquaculture development,
- No commercial operations currently operating, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Within the nation there are no marketing options for cultured marine ornamental commodities. All marketing options are international. The FSM is currently serviced by one jet air craft service (Continental Air Micronesia) which provides on average 6 flights a week to each of the State capitals. These flights either originate Guam and terminate in Hawaii or originate in Hawaii and terminate in Guam for all flights servicing Chuuk, Pohnpei and Kosrae States. All flights services to Yap State originate and terminate in Guam. In addition a specific air freighter is used for the collection and export of fresh tuna destined for the Japanese markets. These flights are operated on availability of fish and fly directly to Asian destinations.

Air Freight availability on all these flights is extremely limited, with passengers and their luggage and postal contractual service obligations given priority over all air freight. Furthermore, restriction on weight to which the plane can carry due to distance travelled greatly reduces freight space and weight considerably. Competition for available freight space is high with the export of local agriculture produce dominating freight space.

Air freight chargers using this carrier to Los Angeles (LA), a major marine ornamental wholesale distribution point are regionally high. Using Pohnpei State as an example for the nation, table 4 provides air freight cost information. Kosrae and Yap States have higher freight chargers and have less freight space availability than Pohnpei State. Whilst Chuuk State charges are slightly lower with slightly higher freight space availability. In all cases, with each air freight shipment a US\$50 administration charge applies.

Table 12. Standard air freight cost for Pohnpei to Los Angeles (per kilogram).

Cost in US Dollars per kg	Air Freight Weight Options
US\$7.24 kg	1 - 44 kg
US\$5.89 kg	45- 99 kg
US\$5.51 kg	100 – 299 kg

The freight charges document above are standard book rates and therefore can be negotiated with prices being reduced in the order of 15-35% depending on regularity of shipping, quantity and long term business development issues. Unfortunately due to passenger demand and the low priority given to freight, regular freight space can not be assured, inhibiting a continuous supply of commodities to international markets.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agencies

National Government	Mr. Valentin Martin Acting Deputy Assistant Secretary for Fisheries Department of Economic Affairs PO Box PS-12, Palikir, Pohnpei, FM 96941 PH: 691 320 2620, Fax: 691 320 2079 Email: fsmfisheries@mail.fm
The National Aquaculture Center	Mr. Mason Timothy Manager PO Box 807, Tofol, Kosrae, FM 96944 PH: 691 370 2069, Fax: 691 370 2651 Email: fisherieskos@mail.fm
Overseas Fisheries Cooperative Foundation (OFCF)	Atoll Resource Management Support Project PO Box 2112, Palikir, Pohnpei, FM 96941 PH: 691 320 8581, Fax: 691 320 3386 Email: OCFCFSM@mail.fm
Kosrae State Government:	Mr. Robert Taulung Chief, Division of Fisheries Development Department of Agriculture, Lands and Fisheries PO Box 82, Tofol, Kosrae, FM 96944 PH: 691 370 3031, Fax: 691 370 3362 Email: fisherieskos@mail.fm

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Pohnpei State Government

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Educational Institutions

Pohnpei Agriculture Training School
(PATS)

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Director
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Private Sector

National

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14.2.2 Marshall Islands

Introduction:

The Republic of the Marshall Islands (RMI) is a young independent nation. It was a United Nations Trust Territory administered by the United States of America (US) until the two nations signed a Compact of Free Association in 1986. The trusteeship was officially terminated by the United Nations in 1990. The compact treaty established a special relationship with the US and provided for economic support to the RMI for 15 years. The funding provisions under the original compact have been recently renegotiated between the two countries to extend this relationship (July 2003). The economic stability of the RMI presently relies heavily on financial assistance available through the compact, with US aid amounting to some 70 percent of the government's revenues (SPREP, 2003) and foreign aid from the international community. The RMI became a member of the United Nations (UN) in 1981 (Miss F. Edwards pers. com., 2003).

The Republic of the Marshall Islands is composed of twenty nine atolls and five low elevated coral islands located in the north central Pacific Ocean (RMI Government, 2000). The majority of the islands are inhabited. The indigenous population is Micronesian with over half the population residing in the national capital of Majuro. The remaining population lives either on Ebeye island on Kwajalein atoll, a large US military installation or on the scattered atolls within the nation. The RMI has an exceptionally high regionally population birth rate (3.89%) and a recent census (July, 2002) count indicated the population within the nation was 73,630 of which half are younger than 15 years of age (RMI Government, 2003). The past decade has witnessed internal migration from the outer lying islands to the nations capital and Ebeye (major center for employment) and an ever increasing outward emigration of the citizen to Hawaii and the United States mainland in search of improved employment and education opportunities (SPREP, 2003).

Traditional, social and cultural institutions are very strong. Marshallese society is based on the extended family, which is responsible for the family welfare, especially in relation to customary family land. Ownership of land and marine areas varies between islands (RMI Government, 2000 and SPREP, 1999). However, the majority of land and marine areas within five nautical miles of the reef are owned by the communities through traditional land ownership and managed in conjunction with atoll local governments (RMI Government, 2000). Land cannot be sold to non-citizens of the RMI. These land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation.

Geography:

The total landmass of the RMI is 181 square kilometres, with a declared EEZ covering 2.13 million square kilometres. The RMI is comprised of 34 islands (coral atolls and low lying coral islands) and the highest elevation is 8 meters. The atolls and islands within the archipelago consist of two roughly parallel island chains: the western "Ralik" ("sunset") and eastern "Ratak" ("sunrise") chains. The atolls extend approximately 1130 km north to south, from 14°43'N to 4°34'N and approximately 1290 km east to west, from 160°48'E to 172°10'E (RMI Government, 2000 & SPREP, 2003). The annual range of surface water temperatures is 27–30°C and the tidal range is about 1.5 m. The nearest neighbors are Kiribati to the south, FSM to the west and Hawaii in the east.

The northeast trade wind belt heavily influences the tropical climate of the RMI. Trade winds prevail from December through April, periods of weaker winds and doldrums occur from May to November. Rainfall decreases as latitudes increase within the archipelagos with annual average rainfall between 60–360 centimetres. The region is affected by storms and typhoons that are more severe as latitude increases and by periods of drought and excessive rainfall associated with the "El Nino" (ENSO) phenomena (RMI Government, 2000).

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. All major types of coral reefs are found within the RMI, including barriers reefs, fringing reefs, large lagoons and submerged reefs associated with atolls. The nation lacks permanent freshwater water flow from rivers and associated estuarine areas. However, isolated patches of mangrove forests and sea grass beds are developed within the nation and several low lying islands have small high salinity lakes located internally. The diversity of marine habitats within the nation provides a wide range of locations that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers of Majuro and Ebeye, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and has accelerated resource depletion, habitat alteration, degradation and in some cases destruction (pers. comm. Marshall Islands Marine Resource Authority - MIMRA). Coastal degradation due to poor land use management practices, sand mining and dredging operations and pollution is a growing concern for the nation (RMI Government, 2000 and SPREP, 2003).

Economy:

The economy of RMI is small and is largely dependent on aid provided through the Compact of Free Association with America, foreign aid and revenues derived from international land leases (Kwajalein atoll and nuclear rehabilitation programs). The US dollar is the currency used by the nation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, wholesale, retail and government services. The government services dominate the economy. The minimal official wage for the private sector is US\$1.50 per hour whilst US\$2.00 an hour is the official government wage (MIMRA, pers. comm.,).

Agriculture, fisheries, and tourism sectors are recognized as providing the long-term growth potential for the nation. Agricultural production and tuna fisheries (international and domestic) are the main commercial business within the islands. The international and domestic commercial tuna fishery provides annual revenues between US\$1 to 3 million dollars (MIMRA, pers. comm.,).

Four thousand visitors (RMI Visitor Authority) entered the RMI in 2002, of which 20% were tourists utilising the nations developing diving industry. Tourism is currently contributing small revenue earnings to the economy of the country. The marine ornamental trade which is dominated by the wild harvest of marine commodities provides a small but consistent contribution to the nation's economy. Aquaculture contribution to the GDP of the nation is negligible, however it is perceived that the culture of black pearls will provide small but steady revenue for the nation in time.

Legislative Issues:

The national constitution of the RMI is the basis for legal authority and decision making for the nation. In addition, to the western style demographic government, a traditional Marshallese governing system including a council of 12 paramount chiefs acts as an advisory body to the national government, especially on matters that affects customary land, law, traditional practices and land tenure (RMI Government, 2000).

Each inhabited island within the nation through its elected local councils holds jurisdiction over their own atoll including land, lagoon and water up to 5 nautical miles offshore from their reefs. These local governments are based on the national legislative system, however have the powers to introduce laws and regulations pertinent to their atoll's affairs. In addition, the traditional hierarchical system of land owners plays a vital role in each atoll's management (RMI Government, 2000 and SPREP, 2003). Therefore, the local island councils and traditional owners have jurisdiction over the majority of coastal areas and therefore are responsible for regulations and enforcement for all marine activities including aquaculture.

Marine and Environmental regulations include those by the national congress, state legislatures and traditional authorities. Two national legislative acts empower to two different government agencies the responsible for the conservation and management of the marine resources of the nation. The Marshall Islands Marine Resources Act (1998) empowers the Marshall Islands Marine Resource Authority (MIMRA) with the responsibility for overall conservation and management of marine resources, including aquaculture. The Marshall Islands National Environmental Protection Act (1984) includes a wide range of environmental legislation that allows the Environmental Protection Agency (EPA) to regulate and enforce. Both acts have specific aquaculture requirements (SPREP, 1999 and 2003).

The RMI is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Aquaculture:

Aquaculture has been the focus of technical development attention in the Republic of Marshall Islands for the past decade with the national government implementing numerous aquaculture initiatives and programmes. These programmes have been designed to provide a means of economic development for the nation through increased local employment opportunities in the private sector and increased natural stocks of certain species through nationwide restocking projects. The vast majority of past and current aquaculture projects for the nation have been developed and undertaken through funding support programmes from a wide range of regional and international donor agencies and managed through both government and educational institutions. The private sector, limited to two main companies has been actively involved in aquaculture development during this time period. Products have been cultured successfully and economic return generated; however information was not available to determine if these companies have attained long-term economic sustainability and profitability for their businesses. Cultured marine ornamental commodities are produced by a single company, which have been active in this trade for well over a decade and are currently producing giant clams, hard and soft corals and experimenting with several species of gastropods and clown fish (MIMRA and Mr. R. Bourke pers. com., 2003).

Aquaculture has been highlighted by the national government as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increasing natural resource stock populations through enhancement programmes, and increasing economic exports for the nation (MIMRA pers. com., 2003).

The national government acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that policies are in place to allow and promote an aquaculture industry and to provide a legal mechanism to effectively regulate the industry as it develops. Much debate still centers on the actually physical and monetary involvement the respective government should invest to develop a viable industry that does produce economic returns and creates long-term employment. Three broad aquaculture categories have been clearly acknowledged within the nation, these include (MIMRA pers. com., 2003);

- Subsistence.
- Commercial.
- Restocking – Reseeding.

RMI has diverse marine ecosystems that provide a range of suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the culture of marine ornamental organisms for the aquarium trade has been undertaken by the national government since the early 1990's. All marine ornamental government and educational facilities programmes that have been undertaken within the nation in the past have been designed and implemented through external funding assistance from a variety of sources. These programs have been based on technology transfer and have provided international expertise to develop land and water based infrastructures (e.g. hatcheries and growout farms), technical information transfer, training and advice to both government employees and the private sector and the opportunity to participate in regional information exchange programmes and attend workshops and conferences (MIMRA pers. com., 2003).

Private sector involvement in culturing organisms for the marine ornamental trade has been undertaken since the early 1990's. These activities have been dominated by one company which has diverse business interests within the nation. This company has operate a giant clam hatchery facility since the 1990's and have focused their marine ornamental activities on the culture of giant clams, hard and soft corals and are currently experiment with the production of several species of gastropods and clown fish. All products cultured are destined for the marine ornamental trade. The export of marine aquarium products has been undertaken since the mid 1990's. Actual production figures and economic returns for these products were not disclosed to the consultant.

Giant Clams:

Giant clams have been artificially cultured within RMI since the early 1990's, both by the government and private sector.

The government's original and primary objective for the culture of these organisms was to restock depleted wild populations through a nation wide training and extension programme coordinated by the national government with assistance from educational facilities (e.g. College of the Marshall Islands). From this initial objective a secondary objective was developed (mid 1990's) to develop community based commercial clam farming to supply clam meat to local markets and to commercially cultured species of giant clams for the marine ornamental trade.

RMI has four endemic species of giant clams (*Hippopus hippopus*, *Tridacna gigas*, *T. squamosa*, *T. maxima*) all of which have been cultured within the nation by both the government and private hatcheries. *T. derasa* has been introduced from Palau in the early 1990's and distributed for reseeded purposes throughout the nation, however very few individuals remain, most of which are held by the hatcheries for broodstock. *T. crocea* has been recently introduced from Palau by a private company to be cultured for the marine ornamental trade.

Stock populations of all endemic species have been reduced considerably over the past two decades, especially in areas close to urban centers and all species have been actively reseeded and are incorporated in marine protected areas within the nation. There is no data available to determine if the reseeded animals remain alive and offspring have recruited.

There are two government owned and operated giant clams hatchery within the nation, located on Likiep and Arno Atolls.

The Likiep atoll hatchery is owned and managed by the (MIMRA) and has been in operation since 1989. This facility is small with a maximum annual production of 5-10,000 one year juvenile clams. The hatcheries main function is to provide clams for reseeded purposes and small scale commercial farms for the nations northern atolls. The hatchery has focuses on the production of *T. squamosa*, *T. maxima* and *Hippopus hippopus*. The development of community owned clam farms has yet to be developed. In more recent times (1996 onwards) all clams of commercial value for the marine ornamental trade have been sold to a private company in Majuro for export whilst revenues gained are used to support the economic requirements of the hatchery (MIMRA, pers. comm., 2003).

The Arno Aquaculture facility has recently been commissioned (July, 2003) and is a jointly managed facility between MIMRA and the Japanese donor agency, Overseas Fisheries Cooperative Foundation (OFCF). The facility has several objectives, one of which is to culture giant clams for a nation wide reseeding programme. The target animal for the reseeding project is *T. gigas* and it is expected that the first batch of clams will be produced in August, 2003. The production of clams from the government hatchery destined to develop commercial community based farms has not yet reach fruition. The government is anticipating the OFCF programme will address these issues and assist in the development of these farms.

There is one private company currently operating within the nation culturing giant clams. Wau Island Mariculture Farm, as subsidiary of Robert Reimers Enterprises has operated a commercial giant clam hatchery since 1990 and has cultured all species of endemic giant clams. Initially the company operated their hatchery facility on Mili atoll and focused their production on *T. gigas* for the meat and shell trade. The company in the mid 1990's relocated their hatchery and growout facilities to Majuro atoll and refocused their programs to target the culture of clams for the marine ornamental trade. This company has actively sold all four endemic species of giant clams and the non-endemic *T. derasa* into the marine aquarium trade. Recently, *T. crocea* has been imported from Palau and shall be cultured and sold into this trade. This facility has the capacity to culture several hundred thousand juvenile giant clams annually and have been a major supply of cultured giant clams in the region. The company in more recent times has diversified its product range and are culturing hard and soft corals (see below) and is currently experiment with several species of gastropods (trochus and turbo) and clown fish (Mr. R. Bourke, pers. com., 2003).

Hard and Soft Corals:

Hard and soft corals are currently cultured in only one facility within the RMI, Wau Island Mariculture Farm. This operation has been culturing and refining techniques on a wide range of soft and hard coral cultivation techniques to develop products to be sold directly into the international ornamental trade. All products are cultured within the company, however the manager expressed his interest in purchasing suitable product from community based coral farmers (Mr. R Bourke pers. com.). As yet there has not been any development of community based operations.

In the past, hard corals have been collected, dried and exported into the international marine curio trade.

Live Rock:

Trade in wild collected live rock has been an on going commercial activity within the RMI since the mid 1990's and is currently undertaken. There has been no activity within the nation to culture live rock.

Marine Finfish:

There has been no commercial scale artificial cultivation of fin fish destined for the marine ornamental trade within the nation. One company however, has experimented with the culture of a local species of clown fish with the production of fish through to marketable size. The production of these fin fish has yet to become a component of the company's regular culture programme (R. Bourke, pers. com., 2003). Over the past decade several marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture.

The RMI also acts as a transit and holding location for marine aquarium fin fish from Kiribati (Tarawa) destined for the US marine ornamental industry.

Marine Shrimp:

There has been no trade in this commodity within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Lack of aquaculture management and legislative policies,
- Limited National and State budgets,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited trained technical and extension staff,
- Limited artificial seed production,
- Limited training facilities,
- Limited interest or motivation in rural communities to undertake new ventures, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Within the nation there are no marketing options for cultured marine ornamental commodities. All marketing options are international.

The RMI is currently serviced by two commercial passenger jet air craft carriers (Continental Air Micronesia and Aloha Airlines) which provide at minimum, daily flights in and out of the nation. These flights originate and return to Guam and/or Hawaii. Continental Air Micronesia operates 6 flights a week; either originates in Guam and terminates in Hawaii or originates in Hawaii and terminates in Guam and connects all State capitals within the FSM as well as Majuro and Kwajalein atolls. Aloha Airlines operates twice weekly flights from Hawaii servicing Majuro and Kwajalein atolls. In addition a specific air freighter is used for the collection and export of fresh tuna destined for the Japanese markets. These flights are operated on availability of fish and fly directly to Asian markets.

Air Freight availability on all commercial flights is limited, with passengers and their luggage obligations given priority over all air freight, however small volumes (up to 150-200kg) of freight can be exported daily using either carrier. Therefore, regular freight space can be assured providing an avenue to create a continuous supply chain to the US mainland based aquarium wholesalers (Mr. R Bourke pers. com., 2003). Aloha Airline services require the transfer of all freight to another carrier in Hawaii, therefore increasing air freight costs and transit times (refer below).

Air freight chargers using Continental airlines as the preferred carrier to Los Angeles, are regionally high. However, due to local long term demand for freight availability for fish/aquaculture freight a specific freight rate charge has been developed by Continental Air Micronesia, which use the cheapest freight rates available irrespective of weight shipped (refer table 5). In all cases, with each air freight shipment a US\$50 administration charge applies.

Table 13. Air freight cost for Majuro to Los Angeles per Kilogram.

Cost in US Dollars per kg	Air Freight Weight Options
Continental Air Micronesia	
Aquaculture Rate	
US\$4.00 kg (US\$1.75kg to Hawaii)	No freight weight restrictions

Cost in US Dollars per kg	Air Freight Weight Options
Standard Shipping Rate	
US\$7.24 kg	1 - 44 kg
US\$5.89 kg	45- 99 kg
US\$5.51 kg	100 – 299 kg
Aloha Airlines (Majuro to Hawaii only)	
US\$50 kg	1 – 18 kg
US\$2.85 kg	18 – 500 kg
US\$2.50 kg	> 500 kg

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agencies

National Government

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Miss Florence Edwards
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College of the Marshall Islands

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14.2.3 Palau

Introduction:

The Republic of Palau is a young independent nation. It was a United Nations Trust Territory administered by the United States until the two nations signed an approval to engage in a Compact of Free Association. This Compact was ratified 1993 and took effect in 1994, with the trusteeship officially terminated by the UN in that same year. The compact treaty established a special relationship with the US and provided for economic support to the nation for 15 years. The economic stability of Palau presently relies heavily on financial assistance available through the compact, with US aid amounting to some 70 % of the government revenue and revenue derived from international tourism. Palau became a member of the United Nations (UN) in 1994 (SPREP, 1999).

Palau is an island chain comprising 200 island and atolls locate in a northeast to southwest direction. The indigenous population is Micronesian which resides on only nine islands with the majority of citizens residing on the main islands of Koror, the nation's capital and administration and commercial centre. The total estimated population in 2002 is 19,900 (SPC, 2003). The past several decades has witnessed internal migration from the outer lying islands to the State capital and an ever increasing outward emigration of the citizen to Guam, Hawaii and the USA mainland in search of improved employment and education opportunities.

Traditional, social and cultural institutions are very strong. Micronesian society is based on the extended family, which is responsible for the family welfare, especially in relation to customary family land. Ownership of land is both privately and state owned. The ownership and management of marine waters and resources are entrusted to the States governments and cover coastal areas out to the twelve (12) nautical miles from the reef (Isamu pers. com., 2003). In all states, land cannot be sold to non-citizens of Palau. These land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation.

Geography:

The total land mass of Palau is 488 square kilometers, with a declared EEZ covering over 629 000 square kilometers (SPC, 2003). Palau is comprised of high and low islands, located in the westernmost section of the Caroline Island group of the southwest Pacific Ocean. It is centred at a latitude of 7° North and a longitude of 134° East with a highest elevation of 242m. The northeast trade wind belt heavily influences the tropical climate with strong trade winds prevailing from December through April and periods of weaker winds and doldrums occurring from May to November. Rainfall is high and can exceed 380 centimeters a year. The region is affected by storms and typhoons and by periods of drought and excessive rainfall associated with the "El Nino" (ENSO) phenomena (SPREP, 1999). The nearest neighbors are New Guinea to the south east, the Solomon Islands to the south, the Philippines to the west, Japan and Guam to the north and the Federated States of Micronesia to the east.

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. All major types of coral reefs are found within Palau, including barriers reefs, fringing reefs, large lagoons, atolls and submerged reefs. In addition, mangrove forests and sea grass beds are well developed especially along the fringes of the high islands and permanent freshwater stream and estuarine embayments are located throughout the nation. The annual range of surface water temperatures is 27–30°C and the tidal range is about 1.5 metres. The diversity of marine habitats and species richness within the nation provides both a wide range of locations and species that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction. The past decade has witnessed the development of National and State environmental regulations and a community wide education program to increase awareness aimed at decreasing all destructive marine practices. Nevertheless coastal degradation due to poor land use management practices and pollution is a growing concern for the nation (Ms. L. Mathews, pers. com., 2003).

Economy:

The economy of Palau is based on aid directly resulting from their Compact of Free Association with the US. Tourism, agriculture and fisheries (international and domestic) are the main commercial activities within the islands, with the tourism sector experiencing considerable growth in recent years and contributing significantly to the nation's revenue. The US dollar is the currency used by the nation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, tourism, commercial offshore fishing, wholesale, retail and government services. The government services dominate the economy. Public and private sectors maintain a government imposed minimal hourly wage structure of US\$2.50. In addition, the private sector, especially tourism, undertakes contractual agreements with non citizens. In these arrangements, remuneration package hourly rates vary and are not confined to the government legislated US\$2.50 an hour.

Fifty three thousand tourists (Palau Visitor Authority) entered Palau in 2002, contributing considerable revenue earnings to the economy of the country and is the nation's second highest revenue earner. The commercial tuna fishery (international and domestic) is the nation's third highest revenue earner for the nation. The marine ornamental trade which is dominated by the wild harvest of marine commodities provides a small but consistent contribution to the nation's economy. Aquaculture contribution to the GDP of the nation is negligible.

Legislative Issues:

The national constitution of Palau is the basis for legal authority and decision making for the nation. In addition, to the western style demographic government, a traditional governing system including a council of 16 traditional chiefs acts as an advisory body to the national government, especially on matters that affects customary land, law, traditional practices and land tenure (SPREP, 1999).

Each State (16 in total) within the nation through its elected local councils and Governor holds jurisdiction over land and water resources up to 12 nautical miles offshore from their reefs. These local governments are based on the national legislative system, however have the powers to introduce laws and regulations pertinent to their State affairs. In addition, the traditional hierarchal system of land owners plays a vital role in each States land and water management (SPREP, 1999).

Marine, coastal and environmental regulations include those by the national congress, State legislatures and traditional authorities. The responsibilities of coastal resource management are spread among the various national government departments and agencies with State governments and local communities taking a major role in these activities in the recent past, which has included enforcement (R. Yanno and Goddard, pers. com., 2003).

Two national legislative acts empower two different government agencies with the responsible for the conservation and management of the marine resources of the nation. The Marine Protection Act (1994) empowers the Bureau of Natural Resources and Development (BNRD) with the responsibility for overall conservation and management of marine resources, including marine aquarium trade activities and aquaculture. The Palau Environmental Quality Protection Act created the national government agency, the Palau Environmental Quality Protection Board (EQPB) which is the statutory body empowered to regulate and enforce a wide range of environmental legislation.

Palau is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Aquaculture:

Aquaculture has been the focus of technical development attention in Palau for well over two decades with National and State governments undertaking numerous aquaculture initiatives and programmes. These programmes have been designed to provide a means of economic development for the nation through increased local employment opportunities in the private sector and increased natural stocks of certain species through nationwide restocking initiatives. The vast majority of past and current aquaculture projects for the nation have been developed and undertaken through funding support programmes from a wide range of regional and international donor agencies and managed through both government and educational institutions. Private sector aquaculture developed during this time period has been limited with neither long-term economic sustainability nor profitability in this sector (Isamu and R. Yano pers. com., 2003).

Nevertheless aquaculture has been highlighted by the National and State governments as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increasing natural resource stock populations through enhancement initiatives, and increasing economic exports for the nation (T. Isamu pers. com., 2003).

The National and State governments acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that policies are in place to allow and promote an aquaculture industry and to provide a legal mechanism to effectively regulate the industry if and when it develops. Much debate still centers on the actual physical and monetary involvement the respective government agencies should invest to develop a viable industry that does produce economic returns and creates long-term employment. Three broad aquaculture categories have been clearly acknowledged within the nation, these include (T. Isamu and R. Yano pers. com., 2003);

- Subsistence.
- Commercial.
- Restocking – Reseeding.

Palau has diverse marine ecosystems that provide a wide range of suitable environmental parameters that are conducive to the culture of a variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the culture of marine ornamental organisms for the aquarium trade has been undertaken by the National government and to a lesser degree the State governments, with almost all of the programmes initiated since the mid 1990's. All most exclusively, all marine ornamental programmes that have been undertaken within the nation in the past have been designed and implemented by the government and educational institutions (public sector) through external funding assistance from a variety of sources. These projects have been based on technology transfer and have provided international expertise to develop land and water based infrastructures (e.g. hatcheries and growout farms), technical information transfer, training and advice primarily to government employees and the opportunity to participate in regional information exchange programmes and attend workshops and conferences (T. Isamu and R. Yano pers. com., 2003).

Palau has been a leading Pacific nation over the past decade that has been involved with development of new technology for the culture of marine ornamental species, namely giant clams and hard and soft corals. Much of this information has been documented and has been disseminated widely throughout the region, including regional training programs on the cultivation techniques for giant clams.

Private sector involvement in culturing organisms for the marine ornamental trade presently and in the past has been minimal. However, several private companies have operated sporadically and have sold cultured giant clams, hard and soft coral commodities. Current annual aquaculture seed production figures and economic values are almost non-existent for all organisms cultured for the marine ornamental trade (R. Yano pers. com., 2003).

Giant Clams:

Palau has seven endemic species of giant clams (*Hippopus hippopus*, *H. porcellanus*, *Tridacna gigas*, *T. derasa*, *T. squamosa*, *T. maxima* and *T. crocea*). Stock populations of all endemic species have been reduced over the past two decades and most species have been reseeded and incorporated in marine protected areas within the nation.

Giant clams have been artificially cultured within Palau since the early 1980's. The original and primary objective for the culture of these organisms was to restock depleted wild populations through a nation wide training and extension programme coordinated by National and State governments. From this initial objective a secondary objective was developed (early 1990's) to develop community based commercial clam farming to supply clam meat to local and regional markets and to commercially cultured species of giant clams for the marine ornamental trade.

There is one government owned and operated giant clams hatchery within the nation. The Palau Mariculture Demonstration Center (PMDC): formerly known as the Micronesian Mariculture Demonstration Center (MMDC). This facility has cultured all seven endemic species of giant clams in large numbers. Cultured clams from Palau have been widely distributed throughout the north Pacific for restocking initiatives and more recently for commercial activities including the marine ornamental and meat/shell trade.

Private sector involvement in culturing giant clams has been confined to water base growout operations utilising giant clams produced from the PMDC which have shown limited long term viability. However, several farms have maintained stocks which are currently selling the smaller brighter coloured species to an aquarium dealer in Palau whom is selling these commodities into the international marine ornamental industry.

Hard and Soft Corals:

Palau was one of the first nations to develop the propagation techniques to cultivate hard and soft corals. This work was undertaken through funding assistance at PMDC during the mid 1990's. This work lead to several private sector companies investing in the propagation of soft corals for the marine aquarium market. The cultivation of soft corals currently is not undertaken within the nation as the company that had been undertaking this work has changed hands (T. Isamu pers. com., 2003). However, the current marine aquarium export company is considering the culture of both hard and soft corals for the marine aquarium market. The cultivation of hard corals, although developed within the nation, has yet to simulate commercial undertaking due to the nation's marine regulations that specifies that all Scleractinia corals must be cultured from aquaculture stocks, hence F2 generation animals must be produce before the sale of these commodities can be undertaken.

In the past, hard corals have been harvested, dried and exported into the international marine curio trade.

Live Rock:

The export of live rock is prohibited by law within the nation and therefore there has been no trade in this commodity. Cultured live rock if produced under the nations aquaculture legislative guidelines would be allowed to be exported.

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past decade several small sized marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture.

Marine Shrimp:

There has been no trade in this commodity within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Limited business management skills,
- Limited access to capital to invest in this sector,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited trained technical and extension staff,
- Limited artificial seed production,
- Very limited interest or motivation in rural communities to undertake new ventures, and
- High air freight cost.

Marketing Opportunities:

Marketing options for cultured marine ornamental commodities within the nation is very limited, with small potential opportunities with several of the large five star resorts within the nation. Several of which have small aquariums operating during the consultant visit. All other marketing options are international.

Palau is currently serviced by four commercial passenger jet air craft services which provide at minimum daily flights into and out of the nation. These flights originate and return to Guam, Japan, Philippines, Taiwan and Korea. In addition, a specific air freighter is used for the collection and export of fresh tuna destined for the Japanese markets. These flights are operated on availability of fish.

Air freight availability on all commercial passenger flights is limited, with passengers and their luggage obligations given priority over all air freight, however small volumes (up to 150-200kg) of freight can be exported daily. Freight services for marine aquarium products destined for the US markets have had limited success to date utilising the Asian carriers. Much of the problems are associated with flight connections to US markets extending time beyond suitable survival rates for the product and/or poor handling of live product within the transit nations. The direct flights to Guam and connections directly to the US mainland using Continental Air Micronesia are providing the best options currently (Belau Aquaculture, pers. com., 2003).

Air freight chargers using Continental airlines as the preferred carrier to Los Angeles, are regionally high. In all cases, with each air freight shipment a US\$50 administration charge applies. However, the standard freight information presented below (table 6) can be negotiated with prices being reduced in the order of 15-30% depending on regularity of shipping, quantity and long term business development issues. Furthermore, regular freight space can be assured which allows the exporting companies an avenue to create a continuous supply chain to the wholesalers.

Table 14. Air freight cost (Continental Air Micronesia) for Koror to Los Angeles (per kilogram).

Cost in US Dollars per kg	Air Freight Weight Options
US\$9.38 kg	1 - 44 kg
US\$7.17 kg	45- 99 kg
US\$6.63 kg	100 – 299 kg

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agencies

National Government	Mr. Theo Isamu Director Bureau of Marine Resources PO Box 359, Koror, Palau 96940 PH: 680 488 3125/2897, Fax: 680 488 1725/1475 Email: BNRD@palaunet.com or Theodmr@palaunet.com
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Private Sector

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14.2.4 Fiji

Introduction:

Fiji gained its independence in 1970, after almost a century as a British colony, is the second largest nation in the Pacific and consists of an archipelago located in the south west Pacific comprised of approximately 320 islands. The indigenous population is Melanesian, however several island groups within the nation are of Polynesian descent (e.g. Rotuma and Lau Group) and the nation has a substantial population of Fijian nationals whom are descendent from India.

Fiji is one of the most developed economies of the Pacific, although still has a large and productive agriculture and fisheries subsistence sector. The nation is endowed with large and productive forests, mineral and fish resources. The economic stability of Fiji presently relies heavily on agriculture, dominated by the sugar industry, forestry, minerals (e.g. gold and copper), clothing, fisheries, tourism and has an active financial and manufacture sectors.

Fiji has a regionally high population birth rate and a census count in 2002 indicated the population within the nation was 823,300 (SPC, 2003), of which half are younger than 20 years of age. The past decade has witnessed internal migration from the outer lying islands and communities to the larger urban centers, especially to the nation's capital, Suva located on the largest island of Viti Levu. There is an outward emigration of the citizen to Australia, New Zealand and further a field in search of improved employment and education opportunities (FAO, 2003b and Fiji Government, 2003). Traditional, social and cultural institutions are very strong. Fijian society is based on the extended family, which is responsible for the family welfare, especially in relation to customary family land. The nation has three types of land tenure; native land, state land and freehold land. Kinship relationships hold native land which comprises of 82.45 percent of the total land area of the nation with one-third reserved for used (leased) by ethnic Fijian nationals, State owned land (9.4 %) and freehold land (8.2%) (FAO, 2003b). The nation has a dual tenure system of governance pertaining to the ownership of all marine resources. State governments possess the legal ownership rights over all reefs and associated resources below mean high water mark and extend out to the outer reef edge. A stipulation included, through legislation and by defacto sense is the right of all native Fijians to fish and utilise the resources of traditional community fishing grounds (FAO, 2003b). These land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation.

The nearest neighbours are Vanuatu and the Solomon Islands to the west, Tuvalu and Wallis and Futuna to the north, Tonga to the east and New Zealand to the south.

Geography:

The Fiji is comprised of approximately of 320 islands of varying sizes with a total land area of 18,333 square kilometers with a declared EEZ covering over 1,290,000 square kilometers (SPC, 2003). These are distributed between 15°-21° S, and 177° E-178° W, with the exception of Rotuma, which lies over 320 km to the north (12-30° S, 177° E) with a land elevation ranging from sea level to 1,324 metres (FAO, 2003b). The main islands of Fiji are of volcanic origin (Viti Levu, Vanua Levu, Yasawa group) although nearly all oceanic island types are found within the nation. The major islands are "high islands" and their interiors are mountainous.

Fiji has a moderate, tropical climate. There are really no marked climatic contrasts in the archipelago, although two mild contrasts are usually noted. First, the main islands are divided into windward (southeast) and leeward (northern and western) sides. Second, there is a recognized cyclone season from November to March (FAO, 2003b). Rainfall averages 200 centimetres on the leeward side and 300 centimetres on the windward side, with weak seasonality. The average yearly temperature is about 25°C, with a slightly lower average on the windward side, and higher average on the leeward side. The relative humidity is high, ranging from 75 to 80 %. Perennial streams and asso-

ciate estuarine systems are located on the larger island of the nations with the majority of smaller volcanic islands possessing intermitted freshwater streams, whilst the atolls rely on sub-surface water lens systems (FAO, 2003b). The largest catchment system in the nation is associated with the Rewa which encompasses 2900 km². The nation has one permanent freshwater lake located on the island of Taveuni (FAO, 2003b).

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found within Fiji, including barriers reefs, fringing reefs, atolls, large lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are especially well developed on the high islands within the nation. Coastal resources are used predominately for subsistence usage (fishing, firewood, construction) and for commercial fishing, tourism and the marine ornamental industry. The annual range of surface water temperatures is 24–29°C and the tidal range is about 2 m (FAO, 2003b). The diversity of marine habitats and species within the nation provides a wide range of locations that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction (FAO, 2003b). Coastal degradation due to poor land use management practices and pollution is a growing concern for the nation (FAO, 2003b).

Economy:

Fiji has one of the largest and most diverse economies of all the Pacific island nations. The economic stability presently relies heavily on agriculture, dominated by the sugar industry, forestry, minerals (e.g. gold and copper), garment manufacturing, fisheries, and tourism and there is an active financial and manufacturing sector. Additionally, the nation has large and diverse subsistence agriculture and fishing sectors. The Fijian dollar (US\$1 = FJ\$1.88, July 2003) is the currency used by the nation and the official minimum labour wage rate is FJ\$1.75 (US\$0.93) per hour.

The economy of Fiji has fluctuated considerably throughout the past two decades. These major fluctuations have been a direct result of political crisis within the nation and in part, to world commodity prices for mineral and agriculture and unfavorable weather conditions (cyclones). Agriculture is the single largest economic sector contributing more than 19% of GDP and employs more than 40% of the nation's total employment, when combined with subsistence agriculture activities it is estimated that more than 80% of citizens are employed in this sector (FAO, 2003b).

The fisheries sector is the fourth largest economic sector contributing 1.6% of GDP, much of this has been due to the recent expansion of both local and international companies targeting large pelagic fish stocks (e.g. tuna). The fisheries sector consists of five sectors, which include; industrial, commercial and artisanal, recreational, aquaculture and subsistence fisheries. Aquaculture contributed 790 metric tonnes of tilapia and marine shrimps with an estimated value of US\$996,857 for the year 2000 (FAO, 2003b). The actual contribution of aquaculture to the GDP of the nation is small; however in context within the Pacific region this production is significant.

The marine ornamentals industries for the year 2001 generated F\$36 million (\$US19 million) in gross export sales and directly employed well over 1000 full time Fijian citizens (Fiji Government, 2003). This is an important industry to Fiji due to its significant economic contribution to the country and the wide distribution of wealth to all stakeholders.

Fiji is a leading Pacific Island tourist destination and the total number of visitors entering the nation in 2001 was approximately 400,000, contributing important revenue earnings to the economy of the country.

Legislative Issues:

The 1990 constitution and its amendments in 1997 provided for a parliamentary form of government based on the British legal system. It comprises 71 elected members; of these 46 are elected by multiethnic electoral rolls and 25 from all communities registered on an open electoral roll. The Senate consist of 32 members of whom 14 are appointed by the president; nine on the advice of the Prime Minister; eight on the advice of the leader of the opposition and one on the advice of the council of Rotuma.

Marine, coastal and environmental regulations are managed by three different official government agencies; these are the Department of the Environment (Ministry of Local Government, Housing and Environment), Fisheries Division (Ministry of Fisheries and Forests) and the Mineral Resource Department (Ministry of Lands and Mineral Resources).

The Department of Environmental has a diverse profile of responsibilities with specific roles in environmental legislation, policy, planning and management of marine and coastal resources. Fisheries Division is responsible for the policy development and regulations of the nation's fisheries, including aquaculture and all activities associated with the marine ornamental industry and the Mineral Resource Department whom are directly responsible for the management, protection and development of coastal zones and environmental impact assessments (SPREP, 1999).

Currently, there is no legislation in place for the long term management and control of aquaculture activities. However, much of this legislation has been incorporated into the "Sustainability Bill" which is currently being reviewed by the nation. The absence of legislation controlling chemical usage, waste discharge and land use is a concern.

Aquaculture development is seen by the government as a priority and the national aquaculture development plan and policies mission statement is "to promote sustainable aquaculture and fisheries development and management as a means of creating employment as well as increasing Fiji's foreign exchange earnings (FAO, 2003b).

Fiji is a signatory to CITES and all regulations pertaining to the trade in these commodities registered with this convention are undertaken by the nation, through the Fisheries Division.

Aquaculture:

Fiji has a limited traditional history of indigenous aquaculture, however since the late 1960's aquaculture has been the focus of technical development of numerous aquaculture programmes targeting freshwater, estuarine and marine organisms. The majorities of these projects were designed to provide a means of economic development for the nation through increased local employment opportunities in the subsistence and private sector and increased natural stocks of certain species through nationwide restocking programmes. Fiji has a long history of introduction of non-endemic aquatic organisms trialed for aquaculture which have included finfish, crustaceans, and molluscs.

The National government through the Fisheries Division acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that polices are in place to allow and promote an aquaculture industry and to provide a legal mechanism to effectively regulate the industry (FAO, 2003b). Much debate still centers on the actually physical and monetary involvement the respective government should invest to develop a viable industry that does produce economic returns and creates long-term employment. Three broad aquaculture categories have been clearly acknowledged within the nation, these include;

- Subsistence.
- Commercial.
- Restocking – Reseeding.

Species currently cultivated within the nation include: tilapia, carp, freshwater and marine prawns, freshwater ornamental fish, milkfish, pearl oysters, giant clams, hard corals and seaweed.

Fiji has diverse marine ecosystems that provide a range of suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

The marine ornamental industry in Fiji has been established for over two decades. The industry has developed with estimated gross export income returns in 2001 of F\$36 million, employing well over 1000 people. The industry is based predominately on wild harvested products, however the development of aquacultured commodities has been undertaken and these products are currently marketing.

The marine ornamental industry came into being in 1983 with the establishment of a single company, Aquarium Fish Fiji Limited located at Pacific Harbour, Viti Levu. The company was restricted to the wild collection of marine ornamental fish with clearly defined boundaries for harvesting and was given a ten year exclusive license. The activities of this company were monitored by the Fisheries Department for adverse harvesting impacts on resource biomass and on the environment. The level of resource harvesting and their impact on the environment was not significantly different from control sites and therefore the government, based on these results opened up the fishery in 1994. Currently six companies are licensed to collect and export ornamentals products within Fiji. These are; Walt Smith International, Ocean 2000 Limited, Water Life, REL Fisheries Limited, Aquarium Fish (Fiji) Limited and Tropical Fish (Fiji) Limited all of which are located on the main island of Fiji, Viti Levu.

The industries long term goal is to transform the marine ornamentals industry, into one based on high product quality and sustainable use of coral reef resources. The government of Fiji is collaborating very closely with the Marine Aquarium Council (MAC) and plays a lead role in the South Pacific in terms of implementing activities to develop a third party marine ornamentals certification system in Forum Island countries. The collaborative work is focused specifically on addressing the range of negative environmental impacts that are occurring or may occur, in conjunction with the existing marine ornamentals industry. The government of Fiji in collaboration with MAC is trying to introduce a market driven certification and labeling system for the marine ornamentals industry that will assist Fiji to achieve a balance between developing profitable reef based industries whilst maintaining reef health, at the same time, minimizing environmental impacts (Fiji Government, 2003).

Fiji, due to its international air freight connections acts as a transshipment center for a wide range of marine ornamental products, some of which are held in Fiji in quarantine systems and reshipped with Fijian product.

Fiji is still at the infancy stage of aquaculture in relation to ornamental species. Only one commercial company, Walt Smith International (WSI) is involved in the mariculture of marine ornamental species. This company has been actively involved in the commercial production of live rock and hard corals and is the leader in this field in the Pacific region (refer below). The Fisheries Division has cultured giant clams for well over a decade and actively sells a proportion of their product to the marine ornamental dealers for sale into the international marine aquarium markets.

There is a small but active freshwater ornamental industry in Fiji culturing fin fish for the domestic freshwater ornamental trade (FAO, 2003b). The main products produced are several species of carp and gold fish.

Giant Clams:

The Fiji has five endemic species of giant clams (*Hippopus hippopus*, *Tridacna maxima*, *T. squamosa*, *T. derasa*, and *T. gigas*) with stocks of the former and last species reintroduced from Australia and Solomon islands. Stock populations of all endemic species have been reduced considerably over the past two decades, with stocks of *T. gigas* extinct.

Giant clams have been artificially cultured within Fiji since the mid 1980's. The original and primary objective for the culture of these organisms was to restock depleted wild populations through a nation wide training and extension programme coordinated by Fisheries Division and the Australia Centre for International Agricultural Research (ACIAR). Resulting from this collaborative effort was trained fisheries personal and a marine aquaculture station built on Makogai Island. This hatchery remains in operation and is currently the only facility within Fiji producing giant clams. The hatchery has cultured many hundred of thousand of juvenile clams of all endemic species within Fiji. From this initial objective a secondary objective was developed (mid 1990's) to develop community based commercial clam farming to supply clam meat to local markets. This secondary objective was further developed in the late 1990's to culture species to be commercial cultured for the marine ornamental trade. Clams cultured at this facility have been sold to local marine ornamental companies and traded into the marine ornamental market, however information pertaining to actual numbers traded is unknown.

The harvesting of wild giant clams (*T. maxima* and to a lesser degree *T. squamosa*) for the marine ornamental industry is not permitted within nation.

Hard and Soft Corals:

Only one company (Walt Smith International) is currently commercial cultivating hard corals within the nation for sale into the international marine ornamental industry. The culture method used is based on removing a piece "frag" of an adult colony and reattaching the piece onto an artificial substrate and on growing the coral to it attaches to the new substrate. The cultivation of parent colonies to be used repeatedly for the removal of "frag" is also developed at this operation reducing the need for wild harvesting. It is estimated that 25,000 individual hard coral fragments from 40 different species are currently under cultivation in lagoon based coral growout farms. Table 7 provides an example of coral "frags WSI cultures (with permission WSI). There is no cultivation of soft corals undertaken for sale into the marine ornamental trade.

The wild collection of hard and soft corals are permitted to be undertaken within Fiji, and like giant clams, are controlled through a regulatory system managed by the Fisheries Division in conjunction with traditional resource owners. Total quantities of hard and soft corals for one Fijian export company (Aquarium Fish Fiji Limited) for the years 2001 and 2002 respectively are 87,570 and 26,696 individual pieces. These numbers are representative of the Fijian industry and the marked decrease in export of these commodities in 2002 has been directly attributed to air freight rates and availability, trade ban on CITES registered commodities (especially in European markets) and a coral bleaching event in Fiji in 2002. Table 5 located in sections 10.2 of this report provides a summary of the type of coral "frags" cultured by Walt Smith International.

In the past, hard corals have been collected, dried and exported into the international marine curio trade.

Live Rock:

Fiji is the largest provider of live rock in the Pacific and this commodity makes up a significant proportion of products exported from Fiji to the marine ornamental industry. All commercial companies currently operating in Fiji collect and sell live rock. Total export of live rock from January to August 2003, for all companies in Fiji was 435.7 metric tonnes, with a monthly range between 36 and 76 metric tonnes. The total value of this export is F\$2,832,050 and it is expected by the industry that the annual value of live rock will in the order of F\$4 million dollars.

Walt Smith International is the only company currently culturing live rock in Fiji. The artificial live rocks are made from coarse sand, hardened with cement and coloured to mimic natural reef rock colours and placed onto the reef, usually in intertidal location. In time, natural settlement of invertebrates and algae occurs and transforms the rock into a live rock commodity. It was estimated (WSI, 2003) that the company has currently 50,000 individual pieces under cultivation which roughly equates to 120 tonnes under cultivation.

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past two decades marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture.

The export of wild harvested marine ornamental fin fish have been a major component of the Fijian industry and fish collection has been undertaken since the inception of the industry two decade ago. As an example of the volume of product sold, 85,000 individual fish were exported by one company in Fiji (Aquarium Fish Fiji Limited) for the year 2000. This is indicative of the scale of operations currently undertaken within the nation.

Marine Shrimp:

There has been no trade in this commodity within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Limited aquaculture regulations including environmental considerations,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited trained technical and extension staff,
- Limited artificial seed production,
- Limited training facilities,
- Lack of legislative systems conducive to coastal and marine leasing arrangements,
- Limited National and State budgets,
- Limited interest or motivation in coastal communities to undertake new ventures,
- Limited private sector interest in commercial aquaculture development, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Fiji is the largest exporter of marine ornamental commodities, both by volume and revenue within the Pacific. All marketing options for marine ornamental commodities are international. Approximately 95 percent of all marine ornamental commodities are air freighter directly to wholesalers in the United States (Los Angeles). The remaining 5 percent of product is exported to European markets; however this market is restricted due to travel times of product. It is understood that a proportion of Fijian based commodities, once landed within the US, and are transhipped onto marine ornamental destination in other nations.

Fiji is services by numerous international and Pacific based airline companies. Marine ornamental commodities are air freighted to US and European markets utilising four main international carriers which include; Qantas, Air New Zealand, Air Pacific, and Air Korea. The preferred flight connections for the marine ornamental commodities are the direct flights to Los Angeles, of which there is at a minimum one flight a day. However, a substantial amount of product destined for the US is transhipped through Australia (Brisbane, Sydney), New Zealand (Auckland) and Korea (Seoul).

Competition for air freight availability on all air craft carriers is high with competition from the fishing (fresh tuna) and garment exporting sectors. Recent discussions with the air freight couriers have been undertaken to alleviate this issues.

Air freight chargers from Fiji to Los Angeles using the above four air line couriers are regionally low. Although each airlines charge rates fluctuate depending on space and weight availability and timing of the year the average freight rate for the year 2003 of marine ornamental commodities has been F\$5.10 per kg (US\$2.70 per kg).

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

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14.2.5 Samoa

Introduction:

Samoa was the first Pacific Island nation to become independent, in 1962, after a period of administration by New Zealand. The economy of Samoa has traditionally been dependent on foreign aid, private family remittances from overseas (New Zealand, Australia, American Samoa, the US), and agricultural exports. Recently tuna fishing has benefited the local economy. Agriculture and fisheries employ over two thirds of the labour force and furnish 90% of all exports, predominantly tuna, coconut cream, coconut oil and copra (URS, 2001). The manufacturing sector comprises of agricultural products and one large automotive wire harness factory. Tourism is a small but an expanding sector. Samoa became a member of the UN in 1962 (URS, 2001).

Samoa is an oceanic volcanic archipelago in the south west Pacific comprises of two main islands, Upolu and Savaii and seven smaller islands. The indigenous population is Polynesian, residing in over 320 villages mainly located along the coast with the majority of people living on the two main islands (SPREP, 1999). The total estimated population in 2002 is 177,800 (SPC, 2003). The past several decades has witnessed internal migration from the outer lying communities and islands to the nation's capital, Apia and a substantial outward emigration of the citizen to American Samoa, United States (Hawaii and mainland), New Zealand and Australia in search of improved employment and education opportunities.

Traditional social and cultural institutions are very strong. The Samoan society is based on the extended family system headed by an elected leader "matai" who represents the extended family in the village council. The collective ownership of the village extends from the reef to inland mountains. Village ownership of coastal waters and resources was formerly universal. While this lapsed in some areas during colonial times it has been widely formalised since the 1990 Fono Act recognised the legality of local government (fono) bylaws (Rimmer et. al., 1999). Land cannot be sold to non-citizens of Samoa. These land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation.

Geography:

Samoa lies in the southwest Pacific between 13° and 14° South of the Equator, and between 171° and 173° West longitudes. It comprises two main islands, seven smaller islands, and islets and rocks. Its total land area is about 2,935 square kilometers, with the two main islands of Upolu and Savaii containing 1,115 km² and 1,700 km² respectively. The archipelago is volcanic in origin are rugged and mountainous with about 40% of Upolu and 50% of Savai'i characterised by steep slopes descending from volcanic crests (Rimmer, et al., 1999). The declared EEZ covers 120,000 square kilometers (SPC, 2003).

Samoa has a tropical and maritime climate, with pronounced wet and dry seasons. The annual range of surface water temperatures is 26–29°C and the tidal range is about 1.5 m. The prevailing winds are from the south-east trade winds (May–October) which drive the ocean currents in the region. Moist, north winds prevail during the warmer months (October–April). Annual rainfall ranges from about 250 centimeters on the coast to over 600 centimeters at higher elevations. The region is affected by storms and typhoons and by periods of drought and excessive rainfall associated with the "El Nino" (ENSO) phenomena (SPREP, 1999).

The capital, Apia is located approximately midway along the north coast of Upolu and lies approximately 130 kilometres from Pago Pago, American Samoa, its closest neighbours. The kingdom of Tonga lies to the southeast and Fiji lies to the west.

Marine Environment:

Fringing coral reefs and their associated lagoonal ecosystems and biomes are the only shallow marine feature of the nation. Lagoonal depths average between 1-m on leeward reefs and 2–3 m on windward reefs. The reef slopes are short and drop quickly into deep waters. The two large islands have little in the way of freshwater resources (Lindsay, 2001). Both islands have mountainous interiors and the rivers are short with small catchments. Consequently, there is considerable temporal variation in river flows. Many creeks and rivers flow strongly after rain, but drop within a few days. There are a number of estuarine systems associated not only with rivers, but also with the numerous freshwater springs that occur commonly on both major islands. Many of these estuaries have been degraded by the construction of the coastal road system, where the construction of solid concrete and rocky causeways has reduced tidal inundation. Mangrove forest and sea grass beds are small but well developed in certain regions of the nation. Some mangrove areas and wetlands have been drained and reclaimed for development (Rimmer, et al., 1999, SPREP, 1999 and Lindsay, 2001).

Marine habitat diversity is limited within the nation which subsequently limits the range of marine species available to be cultured. Nevertheless, there are numerous locations suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction. The past decade has witnessed the development of national environmental regulations and a community wide education program to increase awareness aimed at decreasing all destructive marine practices. Nevertheless coastal degradation due to poor land use management practices and pollution is a growing concern for the nation (Lindsay, 2001).

Economy:

The economy of Samoa is small and is largely dependent on agricultural production for both subsistence and income generation. The Samoan Tala (US\$1.00 = ST\$2.94, July 2003) dollar is the currency used by the nation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, wholesale, retail and government services. The minimal official government and private sector wage is SAT\$1.62 (US\$0.55) per hour (Mr. J. Stanley, pers. com., 2003).

Agriculture, fisheries, and tourism sectors are recognized as providing the long-term growth potential for the nation. Agricultural production and tuna fisheries (international and domestic) are the main commercial business within the islands. The international and domestic commercial tuna fishery provides US\$11,560,000 in annual revenues to the nation in 2002 (Samoan Fisheries, pers. com., 2003).

Samoa received 88,960 visitors in 2002, of which 30% were tourists, and 38 % visiting families. Tourism is currently contributing considerable revenue earnings to the economy of the country. Aquaculture contribution to the GDP of the nation is negligible.

Legislative Issues:

The national constitution of Samoa is the basis for legal authority and decision making for the nation. In addition, to the western style demographic government, a traditional village based social system, based on the extended family unit (the aiga), headed by an elected leader (the *matai*) who represents the aiga in the village council (*fono*) are directly responsible for the management and usage of the marine environment, customary land, law and traditional management (Rimmer et al., 1999). The collectively owned aiga lands extend from the reef to the inland mountains for each village. Sea tenure was formerly universal. While this lapsed in some areas during colonial times it has been widely formalised since the 1990 Fono Act recognised the legality of local government

(fono) bylaws (Rimmer et al., 1999). Therefore, the local village councils have jurisdiction over the majority of coastal and marine areas and therefore play a direct role in aquaculture regulations and management.

Marine, coastal and environmental regulations include those by the national government which incorporates the traditional village authorities and their land and water ownership rights. Two national legislative Acts empower to two different government agencies with the responsibility for the conservation and management of the marine and coastal resources of the nation. The Fisheries Act (1988) and its more recent amendments in (1999) empowers the Division of Fisheries through the Ministry of Agriculture, Forests, Fisheries and Meteorology with the responsibility for overall conservation and management of marine resources, including aquaculture. The Lands and Environmental Act (1989) includes a wide range of environmental legislation that allows the Ministry of Natural Resources and Environment to regulate and enforce. Both Acts have specific aquaculture requirements (SPREP, 1999 and FAO, 2003b).

Samoa is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Aquaculture:

Aquaculture has been the focus of technical development attention in Samoa for several decades with the government implementing numerous aquaculture initiatives and programmes. Aquaculture has been highlighted by the government as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increased natural resource stock populations through enhancement programmes and increasing economic exports (FAO, 2003b).

Private sector aquaculture development within the nation has been limited and long term economic development in this sector has not been realized. During the past decade several companies have operated marine aquarium business. All but one has based their companies on the wild collection of marine ornamental products. One single company, which is currently not operating cultured several species of giant clams for this market.

The government acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that policies are in place to allow and promote an aquaculture industry and to provide a legal mechanism to effectively regulate the industry if and when it develops. Much debate still centers on the actual physical and monetary involvement the respective government agencies should invest to develop a viable industry that does produce economic returns and creates long-term employment. Two broad aquaculture categories have been clearly acknowledged within the nation, these include (Fisheries Division pers. com., 2003);

- Subsistence.
- Commercial.

Samoa is a high island and therefore lacks lagoons; however the nation has diverse marine ecosystems and possesses large reef flats and sheltered bays that are suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the culture of marine ornamental organisms for the aquarium trade has been undertaken by the national government since the late 1980's. All marine ornamental government and educational facility programmes that have been undertaken within the nation in the past have been designed and implemented through external funding assistance from a variety of sources. These

programmes have been based on technology transfer and have provided international expertise to develop land and water based infrastructures (e.g. hatcheries and grow out farms), technical information transfer, training and advice to both government employees and the private sector and the opportunity to participate in regional information exchange programs and attend workshops and conferences (FAO, 2003).

Private sector involvement in culturing marine organisms for the marine ornamental trade has been limited to one single company which operated for several years during early 2000 and currently has ceased operations. This company operated a hatchery facility and has focused their marine ornamental activities on the culture of giant clams. In addition the company had traded in live rock and hard corals, however these were not cultured. Actual production figures and economic returns for these products were not disclosed to the consultant.

Giant Clams:

Samoa has three endemic species of giant clams (*Hippopus hippopus*, *Tridacna squamosa*, *T. maxima*) the former is locally extinct. Both *T. squamosa* and *T. maxima* have been cultured from endemic stocks within the nation by both government and private hatcheries. Additional stocks of clams and additional species has been imported into Samoa for breeding and restocking purposes which has been an on going activity for the past decade. *T. squamosa* has been imported from Tokelau and Fiji, *T. derasa* from Palau, Fiji, Tonga and American Samoa, *H. hippopus* from Australia and Solomon Islands and *T. gigas* from Australia.

Stock populations of all endemic species have been reduced considerably over the past two decades, especially in areas close to urban centers and all species have in the past been actively reseeded and are incorporated in marine protected areas within the nation. A small percentage of reseeded clams remain (July, 2003), however there has been no evidence to date to determine if the reseeded clams have reproduced and resulting offspring have recruited.

The fisheries division has artificially produced giant clams within the nation since the late 1980's. Sporadic and very limited productions of giant clams occurred throughout the 1990's. A new government giant clam hatchery was commissioned in 2001 which has been mandated to culture giant clams for community based reseeded, farming and for commercial enterprises.

Giant clams have been cultured by two private sector companies in Samoa. The first farm (1989-1992) located on one of the nation's small offshore islands was based on hatchery bred juveniles supplied by the Samoan Fisheries Division and imported hatchery bred juvenile's clams from Australia and the Solomon islands. All stock was cultured on intertidal reef flats. Unfortunately, Samoa was hit by two cyclones in 1992's and all stock was lost. The farm did not reopen.

The second privately owned giant clam facility included a hatchery and growout farms. This facility operated from the late 1998-2002. The operation targeted the marine aquarium trade and local sea food markets. This company also sold wild harvested live rock and aquarium fish.

Hard and Soft Corals:

There has been no commercial cultivation of soft or hard corals within the nation for sale into the international marine ornamental industry. However, METI, a Non government organization is currently culturing small numbers of hard corals for a community based coral rehabilitation project. In time, these communities may seek the commercial sale of cultured coral for the marine ornamental trade. In the past, hard corals have been collected, dried and exported into the international marine curio trade.

Live Rock:

There has been no activity within the nation to culture live rock. Trade in the wild collection of live rock has been an intermittent commercial activity within Samoa since the mid 1990's however it has been recently banned. Aquaculture live rock if cultured is allowed to be exported.

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past decade several marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture.

Marine Shrimp:

There has been no trade in this commodity within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Lack of aquaculture management and legislative policies,
- Limited National and State budgets,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited trained technical and extension staff,
- Limited artificial seed production,
- Limited training facilities,
- Limited interest or motivation in rural communities to undertake new ventures,
- Limited private sector interest in commercial aquaculture development, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Within the nation there are no marketing options for cultured marine ornamental commodities. All marketing options are international.

Samoa is serviced by three commercial passenger jet air carriers (Polynesian Airlines, Air Pacific and Air New Zealand) which provide at minimum, daily flights in and out of the nation. These flights originate and return from New Zealand, USA (Hawaii, Los Angeles) and Fiji. Two smaller propeller driven passenger planes provide daily services between Apia and Pago Pago. There is no dedicated freight plane servicing the fishing industry.

Air freight availability on all commercial flights is limited, with passengers and their luggage obligations given priority over all air freight. Furthermore, local competition between export companies (fresh fish and agricultural produce) further restricts availability of freight space for all exporters. This has, in the past and is currently a major limitation to securing regular freight space.

Due to air freight travel times and direct services to the USA, the Air New Zealand flight directly from Apia to LA and/or Apia to New Zealand then to LA are the preferred options of all freight companies dealing with live or fresh products. The freight time is considerably shorter for the direct flight Apia to LA and therefore this flight is a preferred flight option for marine ornamental products. Interestingly, freight from Apia to LA is the same cost whether it is sent directly or via New Zealand.

All air freight exported from Samoa must be sent through a freight forwarding company. Using Air New Zealand as the preferred and cheapest carrier, freight costs are regionally low (refer Table 7). Furthermore, Air New Zealand has developed a special commodity rate for all fish products, which includes aquaculture commodities which further reduces air freight costs. To obtain this special rate all shipments must be of 250 kg or larger. In all cases, with each air freight shipment using Air New Zealand, a US\$40 administration charge applies.

Table 15. Air freight cost for Apia to Los Angeles (per kilogram) using Air New Zealand.

Cost in US Dollars per kg	Air Freight Weight Options
Special Commodity Rate	
US\$1.97 kg (minimum 250kg shipment)	No freight weight restrictions
Standard Shipping Rate	
US\$3.75 kg	1 – 44 kg
US\$3.40 kg	45- 99 kg
US\$2.89 kg	100 – 299 kg
US\$2.72 kg	300 – 499 kg
US\$2.55 kg	500 kg an over

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

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14.2.6 Tonga

Introduction:

Tonga is an oceanic volcanic archipelago in the south west Pacific comprised of approximately 170 islands. The indigenous population is Polynesian, residing on 36 islands with over 65 percent of people residing on the nation's largest island of Tongatapu, which houses the nation's capital Nuku'alofa. The economy of Tonga has traditionally been dependent on agricultural exports, much of which is derived from the export of squash to Japan, foreign aid, private family remittances from overseas (New Zealand, Australia,), and recently tuna fishing and tourism have benefited the local economy.

The total estimated population in 2002 is 101,100 (SPC, 2003) with over 50 percent of the population under the age of 20 (FAO, 2003d). The past several decades has witnessed internal migration from the outer lying communities and islands to the nation's capital, and a substantial outward emigration of the citizen to New Zealand, Australia and the United States in search of improved employment and education opportunities.

Tonga is a hereditary monarchy with the king the head of state and of the government. Traditional social and cultural institutions are very strong. The Tongan society is based on the extended family with collective ownership of the village extends to the high water mark. Ownership of coastal waters falls under the responsibility of the crown and thereby land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation

Geography:

The Kingdom of Tonga lies in the southwest Pacific between 15° to 23.5° South of the equator and between the 173° to 177° West longitudes. The archipelago comprises of approximately 170 islands (of which 36 are inhabitant) running roughly in a north-south axis comprises of three principal groups; Tongatapu in the south, which is the largest island and both the capital and seat of government are located in Nuku'alofa, the Ha'apai group in the centre and the Vava'u group in the north. (SPREP, 1999).

Its total land area is about 649 square kilometers (SPC, 2003) with a declared EEZ covering 700,000 square kilometers (SPC, 2003). The archipelago is comprises of volcanic and mixed limestone and volcanic islands with the highest elevation of 1030 metres located an extinct volcano located in the Ha'apai group (FAO, 2003d). Apart from 'Eua (rising to 330 metres) situated southeast of Tongatapu, there are no other distinct mountains, although on Vava'u hills rise to between 150 and 300 metres. The remainder of the Tongan islands forms a chain of recently formed volcanic islands, some of which contain active volcanoes (FAO, 2003d).

Tonga has a mild to warm maritime climate, with a pronounced wet and dry seasons with temperatures averaging from 23°C in the south to 26°C in the north. As is the case with temperatures, rainfall increases from south to north. The mean annual seawater temperature is 26.6°C with surface temperature highest during February and March. The prevailing winds are from the southeast and the nation is subjected to cyclonic conditions during the summer months between October and March (FAO, 2003d).

The nations nearest neighbours are Fiji to the west, American Samoa, Samoa and Wallis and Futuna to the north and Niue to the east.

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found within Tonga, including barriers reefs, fringing reefs, atolls, large lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are

well developed especially along the fringes of the high islands. Freshwater is variable within the nation (higher rainfall to the north) with considerable variation in annual river flow. Many creeks and rivers flow strongly after rain, but drop within a few days. Estuaries associated with these river systems are common and freshwater springs are present on the reef flats of the high islands when rainfall is plentiful (FAO, 2003d). The annual range of surface seawater temperatures is 27–30°C and the tidal range is about 1 m (FAO, 2003d). The diversity of marine habitats and species within the nation provides a wide range of locations that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction. Coastal degradation due to poor land use management practices and pollution is a growing concern for the nation (SPREP, 1999).

Economy:

The Tongan economy is small and revolves around agriculture for both subsistence and income generation, with tropical produce accounting for nearly 70 % of total exports with squash being the major export commodity. The Tongan Pa'anga (US\$1.00 = TP\$2.40, July 2003) dollar is the currency used by the nation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, tourism, wholesale, retail and government services. The minimal official government and private sector wage is TP\$2.20 (US\$0.91) per hour.

Agriculture, fisheries, and tourism sectors are significant contributors to the nation's economy and are recognized as providing the long-term growth potential for the nation. Agricultural production and tuna fisheries (international and domestic) are the main commercial business within the islands. However, tourism is developing within the nation and has contributed considerable revenue earnings to the economy of the country. 72,430 visitors entered Tonga in 2002. Aquaculture contribution to the GDP of the nation is negligible.

The wild collection and subsequent export of marine ornamental commodities is a significant economic activity for the nation resulting in export earning of US\$1,600,000 for the year 2000. This included both hard and soft corals, fish, invertebrates, live rock and giant clams. Cultured giant clams are the only aquaculture commodity traded with an estimated 13,300 cultured clams exported in the year 2000 (Fisheries per. com., 2003). Nevertheless, the percentage of aquacultured commodities traded in the marine ornamental market is small compared to the collection and subsequent sale of wild harvested organisms.

Legislative Issues:

Tonga is a hereditary monarchy. The King is the Head of the State and of the government. He appoints and presides, over the Privy Council which includes the cabinet (10 permanently appointed Ministers lead by a Prime Minister), the Governors of Ha'apai and Vava'u and any others the King sees fit to call to the council. The legislative assemble comprises of the King and 30 members who include the Privy Council; nine representatives of the hereditary nobles, chosen by their peers, and nine peoples representatives, elected by popular vote.

Sea tenure falls under the property of the crown with the King and government agencies holding jurisdiction over the coastal and marine areas and therefore plays a direct role in aquaculture regulations and management.

Marine, coastal and environmental regulations are managed by two different government Ministries that are responsible for the conservation and management of the marine and coastal resources of the nation. The Ministry of Lands, Survey and Natural Resources which has a wide profile of responsibilities with specific roles in environmental planning and marine parks management and the Ministry of Fisheries whom are directly responsible for the development and management of all living marine resources, including the development of aquaculture (SPREP, 1999). The 1989 Fisheries Act makes no provision for aquaculture development except for a section under Part II, which aquaculture has been incorporated as a fisheries conservation tool and section under Part V which provides provisions on leasing land for aquaculture establishments. Currently there is no aquaculture development policy for the nation, however a draft National Aquaculture Bill has been formulated through technical assistance from FAO in 1999 but as yet been adopted by the government (FAO, 2003d).

Tonga is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Aquaculture:

Aquaculture has been the focus of technical development attention in Tonga for several decades with the national government implementing numerous aquaculture initiatives and programmes. Aquaculture has been highlighted by the national government as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increased natural resource stock populations through enhancement programs and increasing economic exports for the nation (FAO?, 2003).

The national government acknowledged that they have a leading role in promoting the development of a sustainable aquaculture industry. These roles are to ensure that policies are in place to allow and promote of an aquaculture industry and to provide a legal mechanism to effectively regulate the industry if and when it develops. Three broad aquaculture categories have been clearly acknowledged within the nation, these include (Fisheries Division pers. com., 2003);

- Subsistence.
- Commercial
- Restocking – reseeded.

Private sector development within the nation has been limited to trial culture programs for the winged pearl oyster (*Pteria penguin*) and the black lip pearl oyster (*Pinctada margaritifera*) with long term economic development yet to be realized. There are currently no commercial aquaculture facilities producing products for the marine aquarium trade; however the Tongan Government has produced several species of giant clams that have been sold to the commercial marine aquarium dealers for export into this market. During the past decade several marine ornamental companies have operated marine aquarium business within the nation. Currently (2003) four are in existence. All of which base their companies on the wild collection and harvesting of marine ornamental products.

Tonga has a diverse marine ecosystems and posses large reef flats and sheltered bays that are suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the culture of marine ornamental organisms for the aquarium trade has been undertaken by the national government since the late 1980's. All marine ornamental government and edu-

cational facility programmes that have been undertaken within the nation in the past have been designed and implemented through external funding assistance from a variety of sources. These programmes have been based on technology transfer and have provided international expertise to develop land and water based infrastructures (e.g. hatcheries and grow out farms), technical information transfer, training and advice to both government employees and the private sector and the opportunity to participate in regional information exchange programmes and attend workshops and conferences (FAO, 2003d).

There has been no private sector involvement in culturing marine organisms for the marine ornamental trade; however cultured giant clams have been purchased from the government and exported.

Giant Clams:

Tonga has six endemic species of giant clams (*Tridacna gigas*, *T. derasa*, *T. squamosa*, *T. maxima*, *T. tevoroa*, and *Hippopus hippopus*) with *T. gigas* and *H. hippopus* reintroduced from cultured stock from Australia. Stock populations of all species have been reduced considerably over the past two decades, especially in areas close to urban centers and all species have been actively reseeded and are incorporated in marine protected areas within the nation. A small percentage of reseeded clams remain however, there has been no evidence to date to determine if the reseeded animals have recruited.

The Ministry of Fisheries has artificially produced giant clams within the nation since the late 1980's and all species have been successfully cultured for both community based farming and commercial sale to marine aquarium dealers. Three species of giant clam have been cultured and traded through commercial marine ornamental dealers. These include *T. maxima*, *T. derasa* and *T. squamosa*. Table 5 in section 10.1 provides the annual number of each of these species sold into this industry.

Community-based farms, using hatchery-produced juveniles have been developed with the aim of culturing giant clams for the domestic food market. Juvenile clams of less than two years old are supplied free of charge to interested communities which ongrow them to market size. Additionally, training through an extension program and basic supplies to culture clams are provided by the staff of the Ministry of Fisheries. Each species of giant clam has a minimal size limit (shell length) for the harvest of wild clams (260 mm for *T. derasa*, 180 mm for *T. squamosa* and 155 mm for *T. maxima*) and these sizes are also observed by the farming communities. Currently (2003), there are three successful community farms in Tongatapu with about 5,000 to 6,000 each of 5 - 9 year old *T. derasa* and *T. squamosa* and two individual farms in Ha'apai and three in Vava'u (FAO, 2003d).

Additionally, giant clam specimens of *T. derasa*, *T. squamosa*, *T. maxima* are routinely purchased from the Ministry of Fisheries hatchery by the private sector marine aquarium companies and export. The marine aquarium companies exported 13, 298 individual specimens of giant clams in the year 2000 (FAO, 2003d).

Hard and Soft Corals:

There has been no commercial cultivation of soft or hard corals within the nation for sale into the international marine ornamental industry. Currently, all corals exported by the marine ornamental industry are wild harvested. In the year 2000, 40,313 and 26,503 individual pieces of soft and hard corals respectively were exported from Tonga (FAO, 2003d). In the past, hard corals have been collected, dried and exported into the international marine curio trade.

Live Rock:

There has been no activity within the nation to culture live rock. Trade in the wild collection of live rock is an ongoing activity undertaken by the private sector marine ornamental companies. 137.4 metric tonnes of live rock was exported from Tonga in the year 2000 (FAO, 2003d).

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past decade several marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture. 27,545 individual marine aquarium fish were exported for the marine ornamental trade in the year 2000 (FAO, 2030d).

Marine Shrimp:

There has been no cultivation of these commodities within the nation; however they are traded by the marine ornamental traders.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Lack of aquaculture management and legislative policies,
- Limited trained technical and extension staff,
- Limited National and State budgets,
- Domestic Poaching,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited artificial seed production,
- Limited training facilities,
- Natural disasters (e.g. cyclones),
- Limited private sector interest in commercial aquaculture development, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Within the nation there are no marketing options for cultured marine ornamental commodities. All marketing options are international.

Tonga is serviced by six commercial passenger jet air carriers (Royal Tongan Airlines, Polynesian Airlines, Air Pacific, Air New Zealand, Air Fiji and QANTAS) which provide at minimum, twice daily flights in and out of the nation. These flights originate and return from New Zealand, Fiji, Samoa, Hawaii and Los Angeles (USA). Air New Zealand has a direct flight once a week to Los Angeles and this is the preferred option of the marine ornamental companies.

Air Freight availability on all commercial flights currently is not a limiting factor for the marine ornamental companies with several options to export product, some of which are reliant on transshipping in other Pacific island nations (e.g. Fiji).

All air freight exporting Tonga must be sent through a freight forwarding company. Using Air New Zealand as the preferred and cheapest carrier, freight costs are regionally low (refer Table 7). For each air freight shipment a US\$40 administration charge applies.

Table 16. Air freight cost for Nuku'alofa to Los Angeles (per kilogram).

Cost in US Dollars per kg	Air Freight Weight Options
Air New Zealand	
US\$3.70 kg	No freight weight restrictions

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agencies

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14.2.7 Vanuatu

Introduction:

Vanuatu formerly known as New Hebrides was a joint British and French Condominium for 74 years until 1980 when the nation gained its independence. The country subsequently became the 155th member of the United Nations in 1981 (SPREP, 1999). Vanuatu is a Y-shaped archipelago of about 80 islands, of which 67 are inhabited. The indigenous population is Melanesian, with over 50 percent of people residing on the main island of Etate, which houses the nation's capital, Port Vila. The economy of Vanuatu has traditionally been dependent on agricultural, timber, tourism, offshore finance, foreign aid, private family remittances from overseas (New Zealand, Australia,), and more recently tuna fishing. Much of the agriculture and fishing activities are for subsistence usage. The total estimated population in 2002 is 199,600 (SPC, 2003) with over 50 percent of the population under the age of 20 (FAO, 2003e). The past several decades has witnessed internal migration from the outer lying communities and islands to the nation's capital, and a small but consistent outward migration of citizens to New Zealand and Australia and to other Pacific island countries (e.g. Fiji) in search of improved employment and education opportunities.

Vanuatu's national political structure consists of legislative, executive and judiciary branches. The legislative branch consists of a single chamber, the parliament, with 52 seats with the publicly elected members holding seats for 4 year teams. The Executive branch consists of the Prime Minister and the council of minister (9 in total) whom are members of the parliament. The Judiciary branch consists of a Supreme Court with a chief justice and three judges. The head of state is the President of the Republic who is elected by the members of the parliament and the presidents of the six provincial governments for a period of five years. Additionally, there is a National Council of chiefs which acts as an advisory body with issues relating to customs and traditions. The administration of the nation is split into six provincial government areas.

Traditional social and cultural institutions are very strong. The Vanuatu society is based on the extended family with all land owned by traditional landowners which can be an individual, clan or group (FAO, 2003e). Coastal waters including reefs and islets are considered extension of the land and therefore are subject to the same ownership rights (FAO, 2003e). This pattern of land and water ownership is enshrined in the nation's constitution and in a number of land legislation. Land can not be sold to non citizens. Therefore, land and marine ownership patterns greatly influence and complicate access usage for the development of aquaculture within the nation.

Geography:

Vanuatu lies in the southeast Pacific between 12° to 21° South of the equator and between the 166° to 171° West longitudes. The archipelago comprises of approximately 80 volcanic islands (of which 67 are inhabited) running roughly in a north-south axis. The four major islands are; Espiritu Santo, Malekula, Erromango and Efate which combined make up 66% of the total land area.

Vanuatu's total land area is about 12,190 square kilometres with a declared EEZ covering 680,000 square kilometres (SPC, 2003). Most islands are mountainous, rising up to 700m above sea level. Perennial fast flowing streams and rivers occur on most islands with swamps and lakes found throughout the islands, however they are more extensive on larger islands of Santo, Malekula and Efate. It is estimated that 45% of the countries land area is considered potential arable land (FAO, 2003e).

Vanuatu has a warm maritime climate, varying from tropical in the north to subtropical in the southern islands. Rainfall is high with an annual average of 220 centimeters throughout the country, with the northern islands wetter and more humid than the southern islands. There are two distinct seasons, a hot and wet season from November to April and a cool and dry season from May to October. The nation averages two tropical cyclones each year, mostly of which occur during the months of January and February (FAO, 2003e).

The nations nearest neighbours are Fiji to the east, Solomon Islands to the north, New Caledonia to the South west and Australia to the west.

Marine Environment:

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found within Vanuatu, including barriers reefs, fringing reefs, lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are well developed especially along the fringes of the high islands. Freshwater is plentiful, however variable within the nation (higher rainfall to the north). Estuaries associated with these river systems are common and freshwater springs occur commonly on the reef flats of the volcanic islands. The annual range of surface water temperatures is 25–29°C and the tidal range is about 1.5 m (FAO, 2003e). The diversity of marine habitats and species within the nation provides a wide range of locations that are environmentally suitable for the culture of commodities destined for the marine ornamental trade.

Coastal resources, especially close to urban centers, are becoming over exploited. The use of inappropriate and unsustainable fishing practices are being employed which has led to competition between resource users and in most cases has accelerated resource depletion, habitat alteration, degradation and in some cases destruction. Coastal degradation due to poor land use management practices and pollution is a growing concern for the nation (SPREP, 1999).

Economy:

The Vanuatu economy is small and revolves around agriculture and fisheries for both subsistence and income generation, with approximately 80% of Vanuatu's work force involved with agriculture which contributes 25% of the nations GDP. The main export crops are copra, beef, timber and kava. The service sector, which includes tourism, public service and offshore finance, contributes 65% of GDP (FAO, 2003e).

The Vatu (US\$1.00 = VT\$108, July 2003) dollar is the currency used by the nation. The minimal official government and private sector wage is VT\$67.50 (US\$0.62) per hour.

Agriculture, timber and tourism sectors are significant contributors to the nation's economy and are recognized as providing the long term growth potential for the nation. Tourism is developing within the nation and has contributed considerable revenue earnings to the economy of the country. 48 thousand tourist entered Vanuatu in 2002. Aquaculture contribution to the GDP of the nation is negligible.

The wild collection and subsequent export of marine ornamental commodities although ongoing for well over a decade is not a significant economic activity for the nation. The export of marine ornamental commodities include hard and soft corals, fish, invertebrates, live rock and giant clams. The export of wild collected giant clams dominated this market during the years 1998-2000. Cultured giant clams and hard and soft corals are the only aquaculture commodity traded within the nation and to date the number exported is very small (less than 1000).

Legislative Issues:

Marine tenure, like land, falls under the responsibility of the landowners and government agencies holding jurisdiction over the coastal and marine areas and therefore plays a direct role in aquaculture regulations and management.

Marine, coastal and environmental regulations are managed by two government Departments under the Ministry of Agriculture, Livestock, Forestry, Fisheries and Environment that are responsible for the conservation and management of the marine and coastal resources of the nation. The Environmental Unit (Department) has a diverse profile of responsibilities with specific roles in envi-

ronmental legislation, planning, management of marine and coastal resources and the Department of Fisheries whom are directly responsible for the development and management of all living marine resources, including the development of aquaculture (SPREP, 1999). The 1983 Fisheries Act and its amendments make no provision for aquaculture development nor is aquaculture seen by the government as a priority for the nation.

Vanuatu is a signatory to CITES and all regulations pertaining to the trade in these commodities registered with this convention are undertaken by the nation, through the Environmental Unit. Additionally, all marine ornamental commodities exported require a permit issued by the Minister of Fisheries.

Aquaculture:

Aquaculture is not a tradition in Vanuatu and has not been identified in the past as a high developmental priority of the nation. However, in more recent times the national government, communities and the private sector have acknowledged that the development of aquaculture as a potential economic avenue that could provide economic benefits for the nation, including local job creation, increasing domestic protein sources, decreasing fishing pressure on natural resources, increased natural resource stock populations through enhancement programmes and increasing economic exports for the nation (FAO, 2003e). Species currently cultured within the nation for experimental purposes and community awareness/restocking programs included seaweed, tilapia, giant clams, corals and trochus.

Private sector commercial aquaculture development within the nation currently is limited to small scale hard and soft coral farming undertaken in the field for the marine ornamental trade. There is no private sector commercial land based facilities.

The national government operates a small marine Mollusc hatchery that has produced several batches of trochus and giant clams with the former used for a restocking programme and the latter sold to the marine aquarium companies for export into the marine ornamental trade. During the past decade several marine ornamental companies have operated marine aquarium business within the nation. Currently (2003) two are in existence, all of which base their majority of their company's activities on the wild collection and harvesting of marine ornamental products.

Vanuatu has a diverse marine ecosystems and posses large reef flats and sheltered bays that are suitable environmental parameters that are conducive to the culture of a wide variety of marine ornamental species.

Marine Ornamental Culture History:

Historically, the marine ornamental trade within Vanuatu has been based on the wild collection of all commodities (finfish, coral, live rock and giant clams). The national government has cultured small numbers of giant clams designed for this market, however production numbers to date have been very small. Increases in the production of clams from this facility will be realized only after infrastructural and human resource skills are greatly improved. Similarly, hard and soft corals are the only commodity that has been cultured by the private sector to target this market.

The export of marine ornamental products out of Vanuatu has experience difficulties due to the absence of direct flights to USA markets. Currently, ornamental products are air freighted to the USA via Fiji, New Zealand and Australia.

Giant Clams:

Vanuatu has six endemic species of giant clams (*Tridacna gigas*, *T. derasa*, *T. squamosa*, *T. maxima*, *T. crocea*, and *Hippopus hippopus*). Stock populations of all species have been reduced considerably over the past two decades, especially in areas close to urban centers with stocks of *T. crocea* and *T. maxima* heavily exploited for sale into the international ornamental industry in the late 1990's.

The wild collection of *T. crocea* and to a much lesser degree *T. maxima* and *T. squamosa* dominated Vanuatu marine export commodities for the marine ornamental trade between the years of 1998-2000 making up at least two thirds of the quantity shipped (FAO, 2003e). It was estimated that 17,621 giant clams (11,394 *T. crocea*, 4,825 *T. maxima* and 1,402 *T. squamosa*) were harvested from the reefs of Vanuatu in 2000 with an estimated value of US\$80,000 (FAO, 2003e). Concerns over the exploitation rates of these species and the wide spread depletion of the naturally populations of giant clams led the Fisheries Department in 2001 to introduce a total ban on the wild collection and subsequent sale of all giant clam species into the marine ornamental trade. Trade in cultured giant clams is allowed.

The national government through the Fisheries Department have produced vary small numbers of *T. maxima* and *T. crocea* at the government hatchery and as noted above major infrastructure development and human resource capacity skills need to be greatly enhanced before this facility can take on the roll of producing large numbers of clams for growout operations to meet the demand for clams that has been demonstrated by the wild collected specimens.

Hard and Soft Corals:

The wild collection and subsequent exportation of hard and soft coral is prohibited under the Fisheries Act. Corals are currently cultured by one commercial marine aquarium company within Vanuatu for the sole purpose of export for the marine ornamental market. Coral fragmentation culture methods are utilised. Production figures are not available, however fisheries export data indicate that for the year 2000 only 275 pieces of coral where exported as opposed to 6,737 piece exported in the year 2001 (FAO, 2003e). Some concerns have been expressed over the effect the removal of these coral fragments is having on wild stock population and it is recommended that a coral management plan and monitoring program be developed to address these concerns. The development of village based growout farms for corals have yet to be developed.

In the past, hard corals have been collected, dried and exported into the international marine curio trade.

Live Rock:

There has been no activity within the nation to culture live rock. Trade in the wild collection of live rock is an ongoing activity undertaken by the private sector marine ornamental companies with 19 metric tonnes of live rock was exported from Vanuatu in the year 2001 (FAO, 2003e).

Marine Finfish:

There has been no artificial cultivation of any fin fish destined for the marine ornamental trade within the nation. Over the past decade several marine fish aquarium collection companies have operated within the nation, all of which have been based on wild capture. 3,000 individual marine aquarium fish were exported for the marine ornamental trade in the year 2000 (FAO, 2003e).

Marine Shrimp:

There has been no cultivation of these commodities within the nation.

Concerns, Constraints and Development Issues:

- Limited aquaculture development plans,
- Lack of aquaculture management and legislative policies,
- Limited trained technical and extension staff,

- Limited National and State budgets,
- Lack of economic and social assessments for aquaculture feasibility studies,
- Limited artificial seed production,
- Limited training facilities,
- Natural disasters (e.g. cyclones),
- Limited private sector interest in commercial aquaculture development, and
- Restrictive and high air freight opportunities.

Marketing Opportunities:

Within the nation there are no marketing options for cultured marine ornamental commodities. All marketing options are international.

Vanuatu is serviced by three commercial passenger jet air carriers (Air Pacific, Air Caledonia and QANTAS) which provide at minimum, daily flights in and out of the nation. These flights originate and return from Fiji, New Zealand, Australia, and New Caledonia.

Air freight availability on all commercial flights is limited, with passengers and their luggage obligations given priority over all air freight, however current freight requirements for the marine ornamental industry is suitable. However, freight restrictions and lengths of time suitable for the transportation of live marine ornamental commodities is restricted due to the requirement of transshipping all product destined form the US market, irrespective of which air craft carried used. The preferred air freight transportation route is via New Zealand or Australia mainly due to short transport times to these destinations and large availability of additional connecting flights to Los Angles.

The average air freight charge for marine commodities irrespective of quantity sent is US\$3.75 per kg.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agencies

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14.2.8 American Samoa

The information below has been summarized from Curren, 2001.

Introduction:

The United States Territory of American Samoa is a chain of five high volcanic islands and two low lying coral atolls (Swains and Rose atolls). The nation has a total land area of 200 square kilometres and has an EEZ of 390,000 square kilometres. The capital Pago Pago is located on the island of Tutuila which is the centre of economic activity and the nation has an estimated population of 61,000 (SPC, 2003).

The territory exercises limited self government. It has a local legislature and administration that effectively control and provide services similar to those that would be provided at the state and local level in the mainland US. The territory is represented in the US Congress, and all Federal US laws apply. Due to the political compact of free association with the US there has been a history of extensive migration of American Samoans to the US, both Hawaii and the mainland (Curren, 2001).

The economy of American Samoa is dominated by tuna fishing and processing (canneries) on the island of Tutuila, with fishing mostly conducted by US registered purse seiners vessels. Canned tuna accounts for the majority of the nations exports. Additionally, donor aid from the US and family remittances from nationals residing overseas provide an important part of the nation's economy.

Geography:

American Samoa is divided into two groups of islands. A series of five volcanic high islands situated within close proximity to each other and two remote atolls. The volcanic islands annual average rainfall is 300 centimeters, are affected by cyclones between November to April and winds are predominantly from the south-east.

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. All major types of coral reefs are found within the nation, including barriers reefs, fringing reefs, large lagoons and submerged reefs associated with atolls. The high volcanic islands have limited marine coastal areas, much of which have small reef flats and slopes with water descending rapidly once offshore. The atolls have expansive shallow water lagoonal areas. The volcanic high islands have permanent freshwater from rivers whilst the two atolls rely on rainwater catchments and underground water. Sea grass beds and small patches of mangroves are limited within the nation.

Pacific island nations most closely neighbouring American Samoa are Samoa to the west, Niue and Tonga to the south, and the Cook Islands and French Polynesia to the east.

Aquaculture and Marine Ornamental Culture Activities:

American Samoa has a history of experimental culture of marine and freshwater aquaculture species to increase both subsistence requirements and income generation opportunities. The nation in the past (late 1970's) cultured two species of molly (*Poecilia mexicana* and *P. vittata*) to be used as live bait for the tuna fishing fleet. Limited success was attained and the project was terminated. Similar, tilapia was introduced in the late 1950's from Samoa to enhance inland fisheries within limited success.

The government has operated a giant clam hatchery since 1989 on the island of Tutuila and has cultured *Tridacna maxima*, *T. squamosa*, *T. derasa* and *Hippopus hippopus* for reseeding and community based farming programmes designed for the local meat market. More recently, cultured clams from this hatchery have been trialed and sold to the international marine aquarium industry. The government is currently increasing production of clams for this market and is actively working with interested communities and private sector companies to develop both local meat and international

aquarium markets. The local community college has been instrumental in assisting the development of aquaculture and is currently assisting the development of a community based giant clam hatchery for these purposes. Production figures for clams sold to the marine aquarium trade were not available.

The wild collections of marine ornamental commodities, mostly fin fish and live rock have been an ongoing small scale private company enterprise within the nation for over a decade. Live rock originating from Samoa has been transshipped through Pago Pago, however live rock exports within the nation were banned in 2000. The government requires a permit to trade in marine aquarium organisms which applies to both wild collected and cultured products.

American Samoa is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

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14.2.9 Cook Islands

The information below has been summarized from the Cook Island Aquaculture Country Profile. This document should be reviewed for any additional information (FAO, 2003f).

Introduction:

The Cook Islands is located between 156° and 167° W longitude and between 8° and 23° S latitude (central Polynesia), has an EEZ of 1,830,000 square kilometres and a total land area of 237 square kilometre. The country consists of 15 islands that extend over 1,500 kilometres of ocean in a north-south direction. Rarotonga, located in the southern group of islands is the capital of the nation.

The Cook Islands have a political relationship with New Zealand and there has been a long history of migration of Cook islanders from the outer lying atolls to Rarotonga the capital and further a field, mostly to New Zealand. The population of the Cook Islands for 2002 was estimated at 17,900 (SPC, 2003).

The Cook Island economy has been among the best performing Pacific developing member countries over the period 1982-2000, with the economy having grown by 2.8 percent annually in real terms. The economy of the nation is small and is largely dependent on agricultural production for subsistence and income generation. The majority economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, tourism, pearl oyster farming (*Pinctada margaritifera*), wholesale, retail and government services. Black pearls are the nations major export commodity. Donor aid and family remittances from nationals residing overseas provide an important part of the nation's economy. The nation currently has a labour shortage due to emigration of working age adults.

Geography:

The Cook Islands are scattered over a large area of the Pacific Ocean and divided into the two groups, the northern and southern islands. The northern island groups are all coral atolls whilst all but one island in the southern group are raised volcanic high islands with encircling reef platforms adjacent to the coasts. Average temperature in the northern atolls is 29°C whilst average annual temperatures in the southern islands are 25°C. Rainfall varies between islands and the southern islands receive more rain than the northern atolls. The cyclone season is between November to April and winds are predominantly from the south-east.

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. All major types of coral reefs are found within the nation, including barriers reefs, fringing reefs, large lagoons and submerged reefs associated with atolls. The southern islands have permanent freshwater from rivers whilst the northern atoll groups rely on rainwater catchments and underground water. Sea grass beds and small patches of mangroves are well developed within the nation and natural hypersaline ponds are found on several atolls, which are utilised to culture milkfish.

The Cook Islands straddle the Tropic of Capricorn and are located halfway between Hawaii and New Zealand. Nearest neighbours are Tonga to the west, American Samoa and Samoa to the north-west and French Polynesia to the northeast.

Aquaculture and Marine Ornamental Culture Activities:

The Cooks islands have a long history of experimental culture of marine and freshwater species to increase both subsistence requirements and income generation opportunities. The nation's major aquaculture commodity is the black pearl oyster (*P. margaritifera*) cultured for black pearls. The centre of pearl farming is the northern island of Manihiki which relies on the wild collection of spat. Penrhyn atoll is the second largest producer of black pearl relying on both wild collected spat and hatchery reared animals for production. Several other northern atolls are investigating the production of pearls. Pearl farming is a vital income generation activity for the nation, especially for communities on the northern remote atolls.

The government has operated a giant clam hatchery (Araura marine research Station) since 1989 on the island of Aitutaki and has cultured the two indigenous clam species *Tridacna maxim* and *T. squamosa* and three introduced species *T. gigas*, *T. derasa* and *Hippopus hippopus* for reseeded and community based farming programmes designed for the local meat markets. More recently, cultured clams from this hatchery have been trialed through a local marine export company and sold to the international marine aquarium industry. Cost of transporting product from the Aitutaki hatchery to markets and the availability of suitable size and coloured clams have been perceived as an economic impediment to this activity. Additionally, wild collected clams that have been artificially collected on pearl oyster long lines from Manihiki have also been trailed, however due to CITES requirements the importing nations have stipulated these clams are of wild origin and therefore do not meet CITES permitting regulations and subsequently these operations have been put on hold (Mr. I. Bertram pers. com., 2003). The fisheries department is currently developing protocols to address these concerns.

A small number of seeded black lip pearl oysters have been exported and sold into the international marine aquarium industry as a high priced novelty items that allows the aquarist to culture the oyster and in time produce a cultured pearl.

The wild collections of marine ornamental commodities, mostly fin fish have been an ongoing private company enterprise within the nation for over a decade. All animals to date have been collected from Rarotonga and exported to the US marine aquarium markets. The government requires a permit to trade in marine aquarium organisms which applies to both wild collected and cultured products. Specific aquaculture regulations are currently being developed which will include the export of commodities for the marine ornamental trade.

The Cook Islands is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agency

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14.2.10 Kiribati

The information below has been summarized from the Kiribati Aquaculture Country Profile. This document should be reviewed for any additional information (FAO, 2003g).

Introduction:

The Republic of Kiribati is composed of 13 atolls and 4 low-lying islands located between latitudes 5° N and 11° S and longitudes 170° E and 150° W with an EEZ of 3.5 million square kilometres. The nation is divided into three main island groups, the Kiribati (Gilbert), Line and the Phoenix Groups that straddle the equator and the International Date Line.

The 2000 census estimated the total population of the nation to be 84,494 of which 98% of the total population is I-Kiribati. The population distribution of Kiribati is very uneven, with more than 92.5% living in the Kiribati Group with about one third of this number residing on Tarawa, the nation's capital and commercial centre while the remaining 7.5% reside in the Line and Phoenix Groups. Kiribati has a relatively high population growth rate that is estimated to be around 2.1 per cent per annum with 40 % of the population less than 15 years of age in 2000.

The economy of the nation is small and is largely dependent on agricultural production and fisheries for both subsistence and income generation. The majority of economic activities within the nation are subsistence farming and fishing, agricultural production, commercial offshore fishing, seaweed farming, wholesale, retail and government services. Donor aid and family remittances from nationals residing overseas, especially the nation's fishermen provide an important part of the nation's economy.

Geography:

The islands of Kiribati are scattered over a vast area of the Pacific Ocean and have a combined land area of 823 sq. km. The Phoenix group of islands lies approximately 2,000 km to the southeast of the Kiribati group which consists of 3 atolls and 5 table reefs whilst the Line group lies approximately 4,000 km to the east of the Kiribati Group. Kiritimati (Christmas) Island is one of the most populated island of the Line group and known to be one of the largest atoll island in the world and constitutes about 40 percent (321 Km²) of the total land area of Kiribati.

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. All major types of coral reefs are found within the nation, including barrier reefs, fringing reefs, large lagoons and submerged reefs associated with atolls. The nation lacks permanent freshwater flow from rivers and associated estuarine areas. However, isolated patches of mangrove forests and sea grass beds are developed within the nation and several low lying islands have considerable areas of natural hypersaline lakes and ponds. It is these areas that currently support extensive milkfish production within the nation.

Kiribati's closest neighbours are Nauru to the west, Marshall Islands to the north, Tuvalu and Samoa to the south and French Polynesia to the east.

Aquaculture and Marine Ornamental Culture Activities:

Kiribati has a long history of culturing marine organisms and currently through donor assistance is investigating the biological and economic potential of a range of species to increase both subsistence requirements and income generation opportunities. Aquaculture species that have been farmed and successfully cultured are milkfish, brine shrimp and seaweed with pearl oysters and sea cucumber culture currently being investigated. These activities are undertaken throughout the nation.

The wild collections of marine ornamental commodities, mostly fin fish has been an ongoing private enterprise within the nation for over a decade with animals originating from both Tarawa and Christmas islands. Neither operation exports cultured marine aquarium products.

A small scale private giant clam hatchery and grow out nursery farm, targeting *T. maxima* and to a lesser degree *T. squamosa* is culturing these commodities for sale into the marine ornamental trade. Information pertaining to the production and carrying capacity of this operation is unknown at the present time.

Kiribati is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

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14.2.11 Papua New Guinea

The information below has been summarized from the Papua New Guinea Aquaculture Country Profile. This document should be reviewed for any additional information (FAO, 2003h).

Introduction:

Papua New Guinea (PNG) is located between 3-12°S latitude and 141-156°E longitude. It has the largest land mass within the Pacific and has the largest, most sophisticated and most diverse economy of any of the Pacific island states. It is comprised of more than 600 islands including the eastern half of the world's second largest island, "New Guinea", which covers 85% of the country's total land area of 474,000 km².

PNG has a population of more than 5.1 million of which more than 80% residing in rural areas. PNG has an annual growth rate of 3.1% from 1990 to 2000. The majority of the rural population lives in inland areas and depends entirely on subsistence agriculture (and some fishing) for their livelihood. Of the 15% living in urban areas, only less than 50% have a regular income while the others depend on working relatives or other means of survival. There has been a history of migration of younger citizen from rural areas to urban centers with the majority moving towards the national capital of Port Moresby. PNG has one of the Pacific region's lowest literacy rates with a literacy rate of 45.1% for the population aged 10 years and older.

PNG has a very diverse traditional and cultural background and has more than 800 different dialects spoken. English is the main language used in commerce and education while 'tokpisin' and 'hiri-motu' are spoken in New Guinea region and in the Papuan region, respectively.

PNG's economy is based on export of minerals (mainly copper, gold, silver, platinum and oil), petroleum, timber, fisheries and agriculture (coffee, tea, cocoa, palm oil and copra). Natural resources except fisheries are the main revenue earners, while coffee is the main agricultural earner followed by cocoa, copra and oil palm. The Fisheries sector contributes less than 1% to the national Gross Domestic Product (GDP), all of which is from the license fees of foreign fishing boats fishing in PNG waters. Aquaculture does not contribute to the economic base of the country; it is still in the development stage, despite its introduction nearly 45 years ago.

The PNG workforce in the formal sector comprises less than 15% while the mass of the population are engaged in informal sector, mostly in the agriculture-based activities.

Geography:

The islands of Papua New Guinea lie east and north east of the "mainland" and consist of high volcanic mountains and low-lying coral atolls with several active volcanoes. The largest offshore islands are Bougainville, Manus, New Britain and New Ireland. The total coastline is 17,000 km² and the nations EEZ cover an area of about 2.4 million km².

The country has many mountains and ridges that make communication and transportation very difficult. The highest mountain is Mt Wilhelm which has an elevation of 4,509 m. The northern side of the range experiences frequent earthquakes and volcanic activities.

PNG has a tropical climate with little distinct annual variations, though localized variations exist among different locations. Generally it is wet and humid, and temperatures on the coast range from 25-32°C, whilst the highlands are cooler with an annual average temperature of 25°C. Some areas of the highlands experience temperatures below 0°C at times. Annual averages rainfall is 350 centimeters.

About 25% of the land is forested with high mountains and ridges. The rugged mountain topography coupled with a huge annual rainfall forms an impressive catchment for the numerous drainage systems

primarily in the north and south. The Fly and Purari Rivers run south, and the Sepik and Ramu Rivers run north. The flood plains of the major river systems are dominated by swamps and marshlands and large estuarine areas dominate the coastal areas.

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found, including barriers reefs, fringing reefs, atolls, large lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are well developed and cover large areas along the coasts of the mainland and offshore islands.

Closest neighbours are Australia to the south, Irian Jaya (a province of Indonesia) and the eastern half of the island of New Guinea to the west, the Federated States of Micronesia and the Republic of Palau to the north and the Solomon Islands to the east.

Aquaculture and Marine Ornamental Culture Activities:

PNG have been involved in the culture of freshwater and marine organism since the 1950's although the industry has not developed in any significance. Initial attempts were undertaken in freshwater and included subsistence culture of carp (*Cyprinus carpio*), tilapia (*Oreochromis mossambicus*) and cold water rainbow trout. Tilapia culture did not develop, however in more recent time both carp and trout have been produced. Subsistence carp culture is the main aquaculture activity in PNG and concentrated in the highlands region. Rainbow trout culture is a commercial activity that is gaining momentum in the highlands at altitudes of 1,300m above sea level.

The culture of marine species includes the culture of shrimp (Penaeid), barramundi (*Lates calcarifer*) and the black lip pear oyster (*Pinctada margaritifera*). Interest has been expressed from some communities in the culture of sea weed and sea cucumbers.

There has been no commercial production of giant clams, hard and soft corals and live rock for the marine ornamental trade.

The PNG government has a series of regulation that clearly indicates that all marine aquaculture activities are required to be permitted and must meet a series of strict environmental and quarantine regulations. The National fisheries Authority regard aquaculture as a social function which does not contribute to the economic base of the country and therefore this agency has directed its focus to promoting commercial aquaculture ventures through private sector investment.

PNG is a signatory to CITES and all regulations pertaining to the trade in these commodities registered with this convention are undertaken by the nation.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agency

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14.2.12 Solomon Islands

The information below has been summarized from the Solomon Islands Aquaculture Country Profile. This document should be reviewed for any additional information (FAO, 2003i).

Introduction:

The Solomon Islands consists of a double chain of archipelagic mountainous islands and low-lying coral atolls extending over 1,700 km in the southwest tropical Pacific Ocean, between latitudes 5° and 12° South and longitudes 154° and 162° east. The nation comprises over 100 islands and has the second largest land mass of the Pacific island states.

The Solomon Islands has a total estimated population (2002) of 439,400 (SPC, 2003) and an annual growth rate of 3.4% with approximately half the population under the age of 20. Of this population the Melanesians constitute 94.5%, Polynesians 3%, Micronesians 1.2% Europeans 0.2%, Chinese 0.1% and others 0.3%. The bulk of the population is rural dwellers mostly living near or on the coast. The Capital Town Honiara is located on the main island of Guadalcanal and it is developing rapidly. There is a high movement of rural dwellers to the capital in search of work, better schools and clinics.

The Solomon Islands is heavily dependent on subsistence gardening, fishing and hunting. It is estimated that over 80% of the population derived their protein from sea resources whilst these resources provides the second highest foreign exchange earnings for the nation. The main domestic sources of income include subsistence agriculture, forest products, fishing, mining and other services. At the rural level people are more dependent on agricultural crops, fisheries products and mini-trade stores for income. Unfortunately, due to recent ethnic tensions within the nation most industries located on Guadalcanal have been closed. These included timber, phosphate, gold, and tuna.

Land forms an integral part of Solomon Islands way of life. Land tenure system in the Solomon Islands can be categorized into customary and registered. About 87% of the land is customary owned, where a clan, tribe or line owns the land. Unlike customary land, registered land has its owner and boundaries recorded. The land is used for varying purposes but mostly for subsistence gardening although parts of the land are also being used for sub-commercial and commercial purposes such as cocoa, coconut, betel nut, pineapple and coffee plantations. Part of the land is also used for cattle farming.

Geography:

The Solomon Islands has a total of six main islands and 992 smaller islands and atolls contributing to its total land area of approximately 28,370 km². The islands range from bare sand and coralline atolls to large rugged and mountainous islands. The archipelago has a coastline of around 4,023 km and an EEZ of 1.34 million km². Though it has little or no continental shelves, the Solomon Islands possess some of the world's largest lagoons and extensive fringing and barrier coral reefs.

The Solomon Islands has a tropical climate with a relatively high and stable temperature, high humidity and abundant rainfall. It has an average annual rainfall of 200 centimetres and an average temperature of 26.7°C, which varies with topography, latitude and island orientation to the prevailing wind. Relative humidity shows little seasonal variation but has a marked diurnal fluctuation peaking in the mornings. The northwest monsoon, from November to April, brings heavy rains and cyclones. From May through October the southeast areas of larger islands receive a lot of rain whilst the leeward sides experience drier weather. An average of 1.2 cyclones passes through the Solomon Islands each year though not all of these cause damage.

Coral reefs and their associated ecosystems and biomes are the dominant shallow marine feature of the nation. All major types of coral reefs are found, including barriers reefs, fringing reefs, atolls, large lagoons and submerged reefs. In addition, mangrove forests and sea grass beds are well developed especially along the fringes of the high islands.

The eastern reaches of Papua New Guinea are extremely close to the Solomon's, with other near neighbours being New Caledonia and Vanuatu to the south and south east respectively, FSM to the north and Australia to the south west.

Aquaculture and Marine Ornamental Culture Activities:

Solomon Islands have been actively involved in the culture of marine organism since the 1980's and through bilateral arrangements with regional agencies (e.g. ICLARM & ACIAR) have provided valuable biological research into a range of aquaculture commodities for the Solomon Islands and the Pacific region. Most notably are giant clams, pearl oysters and sea cucumbers. Past aquaculture species that have been farmed and successfully cultured are marine prawns, pearl oysters, giant clams, trochus, green snail, corals and seaweed.

The wild collection of marine ornamental commodities, mostly fin fish has been an ongoing private enterprise within the nation for well over a decade. This industry has targeted the US marine ornamental market and has been actively involved in purchasing cultured marine commodities (giant clams and hard and soft corals) from the communities within the Solomon Islands for this trade.

Giant clams and hard corals have been cultured in community based farming operations and sold through local marine export companies into the international marine ornamental industry. These operations have greatly decreased their international trade in all commodities since the ethnic tension. Unfortunately, the largest hatchery that produced giant clams among other commodities was damaged and has ceased operation which has greatly reduce cultured clams available for village farming and the subsequent sale into the marine ornamental trade.

Village based coral farming operations, targeting hard and soft corals has been reinitiated and it is expected that these products will start entering the international marine aquarium markets when production has reached marketing size and quality.

The Solomon Islands aquaculture policy statement clearly states that the government will encourage aquaculture farming and facilitate local participation in accordance to the national fisheries policy statement that ensures all fisheries activities will be effectively managed to attain sustainable use of the marine living resources. Specific aquaculture regulations have been drafted in 2001 and are currently under review before being gazetted.

The Solomon Islands is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agency

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14.2.13 Tuvalu

The information below has been summarized from the Tuvalu Fisheries Profile. This document should be reviewed for any additional information (Tuvalu Government, 2001).

Introduction:

Tuvalu, formerly known as the Ellice Islands under the British Protectorate until 1978 when they gained independence is an archipelago consisting of three small reef islands and six atolls located between 5° N and 10° S and longitudes 176° E and 180° W with an EEZ of 900,000 square kilometres.

The 2002 census estimated the total population of the nation to be 10,100 of with roughly 50% of the total population residing on Funafuti, the nation's capital and commercial centre which has a total land area of 2.5 square kilometres. Tuvalu has a relatively high population growth rate that is estimated to be around 1.4 percent per annum with 40 % of the population less than 20 years of age in 2002.

The economy of the nation is small and is largely dependent on small scale fisheries and agricultural production for both subsistence and income generation. The majority of economic activities within the nation are provided by the offshore marine sector with incomes generated by licensing international fishing vessels which provide about 43% of the GDP of the nation and more than one third of the government income (Tuvalu Government, 2001). Donor aid and family remittances from nationals residing overseas provide an important part of the nation's economy. Tuvalu is presently listed by the UN as one of the least developed of nations.

Geography:

The total land area of Tuvalu is 26 km² composed of nine low lying atolls with the highest point above sea level of the order of five metres. Land based resources are extremely limited and characterised by very poor soils, high salinity and porosity (SPREP, 1999). Coastal erosion arising from wave action and in the long term land inundation from the predicted effects of global warming is a major concern to the nation.

Coral reefs and their associated ecosystems and biomes are the only shallow marine feature of the nation. Most major types of coral reefs are found within the nation, including barriers reefs, fringing reefs, large lagoons and submerged reefs associated with atolls. The nation lacks permanent freshwater flow from rivers and associated estuarine areas.

Pacific island nations/territories most closely neighbouring Tuvalu are Wallis and Futuna, Samoa and Fiji to the south, and Tarawa, Kiribati in the Gilbert Islands to the north.

Aquaculture and Marine Ornamental Culture Activities:

Tuvalu has a small history of culturing freshwater and marine organisms. Aquaculture species that have been trialed and cultured are tilapia (which is currently considered a pest), milkfish, giant clams and seaweed. Giant clams were originally imported into the nation in the 1990's to develop a restocking program aimed at increasing wild stocks within the nation. More recently, the government (Fisheries Department) have instigated the development of a small pilot scale bivalve hatchery designated to culture giant clams for the nations restocking programmes, community based farming for subsistence use and alternative income generation opportunities. One of which is the marine ornamental industry. This hatchery is still in the development stage and therefore no product has yet been trialed into the marine ornamental market. Current limitations on air freight space and the lack of human resource skills in the area of marine ornamental culture and marketing need to be addressed before this industry is likely to develop.

The wild collections of marine ornamental commodities for the marine ornamental trade have not been undertaken in the nation.

Tuvalu is not a signatory to CITES, however the nation has in place a permitting process to regulate the export of all wild harvested and cultured CITES commodities.

Country Contacts:

Additional information can be found in the SPC 2003 Fisheries Address Book (SPC, 2003).

Government Agency

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Fisheries Department
Private mail bag, Funafuti
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Email: ffavms@tuvalu.tv

14.3 Appendix 3: List of Agencies and Organizations

Organisation	Address
Secretariat of the Pacific Community (SPC)	BP D5, 98848, Noumea Cedex, New Caledonia Ph: +687 26 2000 Fax: +687 26 3818 Email: spc@spc.int or BenP@spc.int http://www.spc.int
Pacific Islands Forum Secretariat	Private Mail Bag, Suva, Fiji Ph: +679 312 600 Fax: +679 312 226 Email: info@forumsec.org.fj http://www.forumsec.org.fj
South Pacific Regional Environmental Programme (SPREP)	PO Box 240, Apia, Samoa Ph: +685 21 929 Fax: +685 20231 Email: SPREP@sprep.org.ws http://www.sprep.org.ws
University of the South Pacific (USP)	PO Box 1168, Suva, Fiji Ph: +679 321 2313 / 331 3900 Fax: +679 330 2556 / 330 1490 http://www.usp.ac.fj
Marine Aquarium Council (MAC)	923 Nu'uaniu Avenue, Honolulu, Hawaii, 96817 United States of America Ph: +1 808 537 4509 Fax: +1 808 550 8317 Email: info@aquariumcouncil.org http://www.aquariumcouncil.org
Foundation of the People of the South Pacific International (FSPI)	6 Des Voeux Rd. GPO Box 18006, Suva, Fiji. Ph: +679 331 2250 Fax: +679 331 2298 Email: fspi@fspi.org.fj http://www.fspi.org.fj

14.4 Appendix 4: Travel Itinerary for Consultants

Mr. Ledua Travel Itinerary:

1. Fiji to Vanuatu return (24th – 27th July)

Day 1	Thursday 24th of July	Suva to Nadi to Port Vila
Day 2	Friday 25th of July	Port Vila
Day 3	Saturday 26th of July	Port Vila
Day 4	Sunday 27th of July	Port Vila to Nadi to Suva.

2. Fiji to Tonga return (05th – 08th August)

Day 1	Tuesday 05th of August	Nadi to Tonga
Day 2	Wednesday 06th of August	Tongatapu
Day 3	Thursday 07th of August	Tongatapu
Day 4	Friday 08th of August	Tonga to Suva

Mr. Stanley Travel Itinerary:

Day 1	Monday 14th of July	Apia to Nadi
Day 2.	Tuesday 15th of July	Suva
Day 3.	Wednesday 16th of July	Suva
Day 4.	Thursday 17th of July	Suva
Day 5	Friday 18th of July	Suva to Nadi to Apia

Mr. Lindsay Travel Itinerary:

1. Pohnpei to Palau Return (01st – 04th July).

Day 1.	Tuesday 01st of July	Pohnpei to Koror
Day 2.	Wednesday 02nd of July	Koror
Day 3.	Thursday 03rd of July	Koror
Day 4.	Friday 04th of July	Koror to Guam to Pohnpei

2. Pohnpei to Majuro to Samoa to Fiji return (07th – 21st July).

Day 5	Monday 7th of July	Pohnpei to Majuro
Day 6	Tuesday 8th of July	Majuro
Day 7	Wednesday 9th of July	Majuro to Honolulu
Day 8	Thursday 10th of July	Honolulu to Apia
Day 9	Friday 11th of July	Apia
Day 10	Saturday 12th of July	Apia
Day 11	Sunday 13th of July	Apia
Day 12	Monday 14th of July	Apia to Nadi
Day 13	Tuesday 15th of July	Suva
Day 14	Wednesday 16th of July	Suva
Day 15	Thursday 17th of July	Suva
Day 16	Friday 18th of July	Suva
Day 17	Saturday 19th of July	Suva
Day 18	Sunday 20th of July	Suva – Nadi, Nadi to Honolulu
Day 19	Sunday 20th of July	Honolulu
Day 21	Monday 21st of July	Honolulu to Pohnpei