Provisional Environmental Impact Assessment for the Extraction of Coral Reef Products for the Marine Aquarium and Curio Trade in Fiji

A report prepared for the Fisheries Division, Government of Fiji

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EXECUTIVE SUMMARY

1) Marine aquarium products and curio corals, readily available in Fiji, are in demand overseas. An opportunity exists to take advantage of this market.

2) Concern exists as to the environmental effects of removing organisms and coral rock from the coral reefs. This is particularly with regard to the compromising the subsistence and artisanal fisheries.

3) With the advent of the "mini-coral reef aquarium" there has been a growing market for live coral, both hard and soft, and a number of other reef creatures such as clams and anemones.

4) Six companies are operating in Fiji. Four export live coral and *live rock* and two are concerned with curio coral export.

5) The export of aquarium products and curio coral been increasing with good prospects for a continued expanding market.

6) Permit issuance and subsequent record keeping by the Fisheries Division needs to be reviewed. The use of the inflated export numbers as actual exports is in error. The trans-shipped material through Fiji needs to be accounted for.

7) Interviews with the resource custodians indicated a divided opinion on the effect *live rock* and curio coral removal on their fishing areas.

8) Management responsibilities between the resource custodians and the Fisheries Division with respect to coral are unclear.

9) Environmental impact is difficult to assess in the short term. Monitoring over a period of two years is recommended with reassessment at that time. Natural variation in coral reefs makes field observations difficult to resolve in terms of the effect of collection. The size of the areas of collection and the numerous nature of benthic inhabitants prevent acquisition of accurate estimates of species presence and abundance. A more extensive sampling program is outside the scope of this study. Such assessment has only been undertaken on a small scale. Collection in all areas of coral products extraction appears sustainable in the short term (2 years). Collection in the worst case, results in the depletion of that species in the area of collection. The ability to recolonise from parental material at depth or from other reefs is a certainty as is evident from the restoration of reef communities after a natural disaster such as a flood or cyclone.

10) Collection live coral products appears to be sustainable based on the limited size classes required and the extensive reef area available for collection.

11) The sale of hatchery reared *Tridacna* clams should represent a maricultural market success. Collection of wild material competes with a food resource and contributes to the depletion of the stock already reduced through over-fishing.

12) *Live Rock* collection can be engaged with minimal environmental impact on the local fishery. In some cases, however, this practice has been highly destructive to the existing reef flat and lagoon.

13) Curio coral collection, more than other types of collection, represent the removal of species and size categories from shallow reef tops. The size of the collection areas allow for an abundant

resource. The reefs remain luxuriant through the proliferation and replacement by non-commercial species. The effects of this cannot be determined without a concentrated survey of the area prior to collection. However, it should be noted that alteration of the reefs as the result of collecting is not readily discernable.

14) The Fisheries Act needs to be reviewed with relevance to this industry. Licensing needs to be brought into line with the Act. Export permits need to be brought under the jurisdiction of the Fisheries Division.

15) Guidelines are presented that should, if properly implemented, effectively manage this emerging fishery.

1.0 INTRODUCTION

Commercial collection of the living material from coral reefs for export has caused concern with regard to its environmental impacts and sustainability. The requirement for aquarium products and curio coral is growing rapidly. Its management at both the community and Governmental level is lagging due to the unclear status of the fishery. The resource represents a valuable export but the emerging nature of the fishery prevents management, traditional or otherwise, which is based on biological data or ecological relationships other than in a categorical sense. No statistical comparison of the effects of extraction are immediately possible due to the lack of both baseline data and history of observation.

This report discusses the current state of the aquarium products and coral harvesting industry in Fiji. The fishery utilizes coral as ornaments and live coral, plants, other animals and reef rock for coral reef aquaria. Collection for other uses such as for medical purposes, the construction of sewerage soakage pits and for other constructional purposes is only briefly considered.

The objective of this report is to provide an overview, which differentiates between the different types of reef product collection so that a more informed appraisal of the issues of conservation and management can be made. It is directed to policy-makers, resource owners and users, and those who are interested in understanding the various points of view concerning this emerging fishery. The history and trends in the different activities are assessed. Statistics are presented on the quantity of product exported.

A summary of the current debate and contentious issues concerning coral harvesting activities are presented. These include the objective appraisal of the ecological, biological, social culture, legal, political, and economic issues. The concept of sustainability and conservation, as it applies to Fiji, is discussed.

Management responsibilities are assessed, as well as current government regulation and policies, including the current policy on licensing. Successful management will depend on the development of policies which allow the operation of the industry in a competitive environment as well as promoting a sound emphasis on sustainability of the resource and other fisheries resources which it is likely to impact on. Recommendation and guidelines are suggested as to *best practices.* The views of the resource owners are assessed through interview. Assessment of the current practices and mechanisms of the harvesting of coral were made.

1.1 Global Coral Trade

From CITES information, 70 nations imported a total of 34,600,000 pieces of coral products from 120 exporting nations during the period of 1985-1997. The USA accounted for 56% as compared to 15% for the EU. Asian exports were an order of magnitude more than their Pacific counter parts. Recently, Fiji and the Solomon Islands have become prominent exporters. The top ten exporting nations are Indonesia (41%), China (24%), Philipines (18%), Fiji (4%), Taiwan (2%), Solomon Islands, Vietnam, Marshall Island, Tonga and Mozambique (all at 1%). Thje top ten importing nations are the United States (56%), Hong Kong (14%), Japan (12%), Germany (8%), Italy and France (both at 2%), Spain, United Kingdom, Netherlands and Portugal (all at 1%) (Green and Shirely, 1999)..

1.2 Opportunity: The Market Place

The market for both whole coral colonies and live aquarium material is large. Bleached or coloured coral has always provided both fascination for and an appreciation of nature. Within the last decade this

fascination as has evolved to include live *mini-reefs* in aquaria. This has been possible through the technological advances in lighting, filtration and an increased awareness of the dynamics of marine aquaria.

In 1986, TRAFFIC (U.S.A.), the American branch of the World Wildlife Fund that tracks international trade in endangered plants and animals, estimated that there are 10 million marine aquarium hobbyists. Estimated sales are $1.6 billion of the $4 billion spent on the aquarium trade worldwide. The fastest-growing segment of the industry is the *mini-reef*, where aquaria range in size from 15 to several hundred gallons and cost, when fully stocked with colorful and exotic marine fish and invertebrate, from $1000 to tens of thousands of dollars. Sales of marine aquarium in the United States now make up 15 percent of the country's total with the popularity increasing. According to industry figures produced by the Pet Industry Joint Advisory Council in 1999, 0.6% of American households maintain 622,000 marine aquaria with most probably 90% of these or 560,000 being tropical. It is estimated that 6 million pieces of live coral, 18 million pieces of soft coral and 50,000t of live rock are being maintained in these aquaria (Green and Shirley, 1999). North American hobbyists spend some $240 million a year on equipment and animals, with seemingly no limit to the desire to create mini-coral reefs in there own homes.

With Fiji located in tropical waters where reefs flourish and there is a natural abundance of marketable coral reef products, a well managed and sustainable industry presents the opportunity for additional income for coastal peoples. This rapidly growing market for reef products, presents a challenge for reef managers, both customary and institutional, to determine whether coral reefs can produce additional benefits without compromising the present ones.

1.3 Concerns

With the opportunity of selling coral reef plants and animals to a global market, the issue of sustainability is raised. Perhaps more important is the prospect of potential harm to the reef fisheries which the villages are so reliant on. The challenge in engaging in this new industry is to develop a balanced appraisal of the pros and cons of the varied activities with respect their affect on the reef. How are we to determine what type of harm is being done? Can the perceived negative impacts be minimised through management and adherence to 'best practice' methods? Are some of the negative impacts acceptable, given that substantial income is derived? These questions are part of the discussion about this new industry whose limits for growth appear immense in terms of market potential and in developing the resource available in Fiji.

2.0 DEFINING THE INDUSTRIES

Historically, the term *coral harvesting* has described all activities concerned with the collection of coral. Previously, it involved almost exclusively the collection of hard coral for their decorative skeletons. Currently, this distinction has broadened to refer to the removal of a wide variety of plants, animals and reef material for commercial benefit. Coral reef derived products have only a limited local market. With the exception of septic system material, all products are for export. The main activities in Fiji can be divided into the collection of material for:

CURIO OR ORNAMENTAL CORAL: This involves the removal of whole hard coral colonies. They are collected for the purpose of selling their cleaned skeletons as decorative items.

LIVE AQUARIUM PRODUCTS: The general collection of reef organisms which are amenable to aquarium life and includes hard and soft coral, and mobile invertebrates such as gastropods, crustaceans and starfish.

LIVE ROCK: This is the collection of reef rock covered with coralline algae, which is used as a partially living substrate in creating relief or seascape in aquaria. It is a composite material of skeletal material of algal or coral origin and associated plants and animals. The "live" part of the live rock refers to the coralline algae covering the surface. This may also reflect the fauna or flora which resides on or within. One of the principal functions of this coral based substrate is bio-filtration. The living substrate of the rock , algae and bacteria, remove organic waste products such as nitrates, phosphates and stabilize the water parameters of pH and alkalinity. The bacteria have the capability to perform a nitrifying role in converting ammonia to nitrate and a denitrifying role in reducing nitrate to nitrogen gas.

Other Coral Products:

Live Sand is exported for the aquarium trade but, at present, in small quantities. *Live Sand* is preferred as it is composed of carbonate material as opposed to sand of terrestrial origin. Diatoms and the calcareous alga contribute substantially to this material. It is used industrially for the production of cement, mortar and agricultural lime. Corals are also taken infrequently for the medical purposes and for scientific research, but these represent small amounts. The removal of massive corals for the use in sewerage soakage pits is discussed.

Depending on the type of collection, the practices are substantially different in their operation and impact. Extraction for aquarium products involves the collection of a large number of different organisms and reef rock. In many cases, the life histories and ecological impact of their removal is speculative. To lump all coral extraction together as *coral harvesting* is a mistake and has led to confusion and error in assessment of benefit and impact.

2.1 Issues

Concerns over the activities of these industries are based in the negative impacts that they may have on the coral reef systems. It also brings to light the problems associated with the industries management. This area is complicated by the dual tenure system whereby responsibility for management is shared.
Further confusion has occurred when ecological theory is taken in its most general sense and applied to specific activities. An example is the simplistic perception that the extraction of coral is detrimental because it involves habitat removal which, in general terms, must impact on all the living organisms associated with coral and, ultimately, on the productivity of the area's fishery. Another conception is that the corals themselves are fundamental in the recycling of nutrients in the system and are important sources of food, themselves. The predator/prey relationships involving corals are incompletely known but are important in maintaining the balance of a coral reef ecosystem (Connell, 1973; Pearson, 1981). Assessment of impacts is further complicated by the collection of a wide variety of organisms other than hard coral.

Coral reef management itself is a cause for concern. In Fiji, the dual tenure system which combines the responsibilities of the central Government with those of the traditional custodians of the qoliqoli's to work in a partnership to manage the inshore fishery. The precise legal nature of this relationship is unclear. This gives rise to problems when the management of the resource is considered.

Conservation oriented care of reefs has generally opted for a cautious "don't interfere" with nature approach. The history of coastal peoples relationship with the reef as a subsistence fishery, is one of a constant, renewable resource in which can be relied on to support their general well being. The traditional approach of the custodians is to take advantage of the reef cycles where abundance may be seasonal. Cyclones and the *crown-of-thorns* starfish events has provided an understanding of the resilience of the reef as a resource. The prospect of the removal of reef products, at best, is an added source of income

and, at worst, a temporary depletion of the new fishery and traditional food items. If the problems warrant, a tabu or prohibition on collection will be declared to allow the system to regenerate. Other impacts include the increase of nutrients in nearshore waters from larger coastal populations due to pollution effects from sewerage and from agriculture. As well, pollution of coastal waters through soil erosion, and salinity changes due to increased run-off continues to take a toll on coral reefs in more recent times.

Broad questions emerge as to whether the removal of additional reef products are acceptable in terms of its sustainability or whether there is sufficient material to allow the 'mining' of accumulated reef rock.. Little is known as to whether these extractive practices maybe considered good reef management in beneficially altering a portion of a reef environment. Another issue is the extent to which customary rights allow for the management of the qoliqoli resources, particularly when it results in extensive alteration of the reef environment. Or whether extensive alteration of the reef may be considered acceptable, and the rightful decision of the resource owners. Importantly, is the determination as to how destructive the practices really are and how long it would take a reef to return to its 'natural state'.

Ecological damage considered, the coral harvesting companies maintain that the industry is of greater benefit to the local community than the harm done to the reef or its resources. They feel that training in extraction techniques encourages minimum damage to the reef during coral removal. Market demand, in some cases, limits the extraction. In most cases, generally fast growing species are taken which increases the probability of a sustainable fishery and the ability of the species to replenish if they were to become depleted.

2.2 Types of coral reef plants and animals collected -- Scientific Classification.

The hard coral species taken for the curio and the live aquarium trade are similar. Though they may differ in the composition of species taken, the main difference is that the curio trade requires a wide range of sizes most of which are larger than that required by the aquarium trade.

2.2.1 Classification or Taxonomy of Organisms taken for the Curio and Aquarium trade

Phylum Coelenterata (synonym Cnidaria)

Class Anthozoa

Subclass Zoantharia (synonymous Hexacorallia)

Order Scleractinia -- Stony or Madreporarian corals (Appendix 14.1 for full species listing for the curio trade): Any (non-massive) species with an attractive growth form qualifies for collection. With the live coral trade the fleshy appearance of the coral is an important attribute as is their susceptibility to aquarium life.

Order Antipatharia -- Black coral. Formerly utilised in the production of local jewelry production. Not currently exported.

Order Actinaria -- Sea anemone

Order Corallimorpharia -- Coral or Mushroom anemones

Order Ceriantheria -- Tube anemones

Order Zoanthidae -- Colonial anemones

Subclass Alcyonaria (synonymous Octocorallia)

Order Coenothecalia -- Blue corals (Heliopora sp.) Present only in Rotuma

Order Stolonifera -- Pipe organ coral (Tubipora sp.)

Order Gorgonacea -- Sea fans, red coral

Order Alcyonacea -- Soft corals

Class Hydrozoa

Order Milleporina -- Fire coral (Millepora sp.)

Order Stylasterina -- Lace coral (Stylaster sp.;
Distichopora sp.).

Class Scyphozoa -- Jelly fish

2.2.2 Other Live Coral Reef Animals: Classification of Invertebrates (Aquarium Specimens)

Phylum Porifera –Sponges

Phylum Annellida
Class Polychaeta
Family Serpulidae or Sabellidae Worms -- Fan Worms and feather duster worms

Phylum Mollusca
Class Gastropoda-- Snails
Class Opisthobranchia-- Nudibranchs
Class Pelecypoda-- Scallops, Mussels, Oyster, Giant (Tridacna) clams
Class Cephalopoda-- Squid, Octopus, Cuttlefish and Nautiloids

Phylum Arthropoda
Class Crustaceans: Crabs, Lobsters and Shrimps

Phylum Echinodermata
Class Asteroidea-- Starfish
Class Crinoidea-- Feather stars
Class Ophiuroidea-- Brittle stars
Class Echinoidea-- Sea urchins
Class Holothuroidea-- Beche-de-mer

3.0 THE TYPES OF EXTRACTION AND THE COMPANIES OPERATING IN FIJI

Following are descriptions of the companies involved in the extraction of reef products.

3.1 Collection of live organisms (Fig 1a-h)

This activity involves the removal of live reef organisms and subsequently the holding and packaging for trans-shipment to the foreign destinations. The collection in all cases is contracted out to villages with a qoliqoli (customary reef rights area) from which divers collect specified reef animals. No underwater breathing apparatus is used (except with Fisheries Div. exemption) and collection is from relatively shallow reef areas <6m. The divers are trained in the removal and care of the organisms during transit back to the holding facility. The means of capture involves removing the organism with an iron bar, chisel or screwdriver, which preferably includes a small portion of the reef to which it is attached. Most of the hard and soft corals are collected as whole colonies but some are fragmented. Both branching and massive species of hard coral are collected. In the case of the hard and soft coral, the size of the material is limited (<15 cm diameter) by the nature of the market demands. In the case of the anemones, they may be much larger.

Upon collection, the material is brought back to the boat where it is protected by placing the specimen in sealed plastic bag of water with an air space or covered with a plastic wrap to prevent injury. These are placed in a holding bin until unloading at the holding facility.

Figure 1: Live Coral : Hard and Soft

a) Live coral collectors prepare for the days work.

b) Diver removes hard coral from its reef attachment.

c) Soft coral *Xenia sp.* are removed form their boulder substrate.

d) Collectors place specimens in water filled plastic bags for transport to the holding facility.

e) The hard coral *Tubastrea sp. (below)* and *Turbinaria sp.* (above) await shipment at the Walt Smith Int'l warehouse.

f) Part of the day's collection of hard corals at Ocean 2000's holding facility.

g) Giant clams of *Tridacna sp.* are held for shipment. The wild specimens have a bright coloured mantle, which has more value on the retail market (left). Hatchery reared specimens occupy the two trays to the right of the photo.

h) Refrigeration units for water temperature control (foreground), protein skimmers (top center) and metal halide lamps provide an environment that keeps mortality low.

The holding facilities among the live coral collectors varies but the most sophisticated and of greatest capacity is that of Walt Smith International in Lautoka where there are five separate holding systems for the live aquarium products. One of these is live rock and will be dealt with in a separate section (3.1.3). This includes, hard and soft coral, *Tridacna* clams, anemones and starfish. The system devoted to anemones and starfish has a capacity of 6800 l., comprising three 8'x 4' flat tanks. Two of the systems, which can be linked, are devoted to (1) clams and hard coral and (2) only hard coral. The combined capacity is 27,240 l. An isolated system is devoted to soft corals which has a capacity of 31,780 l. There is also a system of equivalent volume devoted to tropical fish. Each system has a 50% water change every week. The holding tanks are illuminated by a large array of metal halide lamps, which mimic the solar spectrum. High water quality is maintained by regular water renewal, filtering with mucus and biological residue removed through a protein skimmer. Refrigeration is used to maintain the facility water temperatures at sea temperatures. The water is sterilized by ultra-violet light, ozone injection and chemical additives (fish), which provide additional anti-bacterial protection.

With this level of technological support, mortality is limited during the transition from the natural reef environment to that of the wholesalers aquarium. Care at this early stage in the collection and holding is important in providing a product to market, which assures good survival for the end consumer. Not all of the facilities in Fiji meet this standard.

For trans-shipment abroad, the material is repacked into water filled, oxygenated plastic bags and shipped out several times weekly by air freight. Generally, this is to the United States but worldwide interest in aquarium products has opened up markets elsewhere.

The five companies that engage in this enterprise are Ocean 2000, South Seas Export, Walt Smith International, Waterlife, Fiji and Aquarium Fish (Fiji) Limited. Details of the companies are as follows:

3.1.1 Ocean 2000 Ltd.

The proprietors of the company are Nemani Turagaiviu and Tai Hancock. They are the second largest company in terms of product exported. This operation is based in Nausori but has a warehouse in Nadi to assist in the trans-shipment of live rock.

They have 14 employees with two casuals involved in the packaging and dispatch of live material. The collection is subcontracted to Vatani Village on Kabuna where there are up to seven boats with 20 divers operating. Their current area of live collection is in Kabuna Waters and Motoriki I. Ocean 2000 Ltd contracts its *Live Rock* collection through Malomalo Village and employs 10 families, comprising a workforce of 30. Their Nadi operation has 8 staff and 5 casuals. Their Suva office has 3 employees.

Their live coral holding facility is 27,000 l.. It has a protein skimmer and sand filters. The live coral facility has its own water reservoir which is sand filtered and circulated though cement troughs. The reservoir is set into the ground 3.5m to take advantage of natural cooling. No UV or other sterilization methods or refrigeration are employed. The holding area has natural lighting. The live coral system is isolated from the fish system which has a capacity of 18,000 l. The fish system has a protein skimmer, fluidized sand bed and a UV sterilizer. An airconditioner cools the fish romm.

3.1.2 South Seas Export Ltd.

The proprietors of this company are Ratu Epenisa Cakobau and Elwyn Segrest. The holding facility is based in Wailada, Lami and is utilized mainly for the export of aquarium fish but they are progressively exporting more coral. Their current area of collection is in Suvavou, Rewa and Kabuna waters. They have 8 employees. The South Seas Export facility has a regularly replenished seawater reservoir, UV sterilization, a protein skimmer and refrigeration for temperature control.

It contracts its *live rock* collection through Komave Village where the product is collected from Vatumalawa Reef. They have no holding facility. The product is packed on the beach and exported immediately.

3.1.3 Walt Smith International Ltd.

The proprietors are Walt and Deborah Smith who are in partnership with Loti Rasiga. They have 36 employees in the warehouse, who are involved in the care of the system and reef products, processing of the live rock, and packaging for export. The details of the live animal seawater systems have been presented in the introduction to this section.

The contracted field workers number 65, with 43 of these from Vatukarasa village where they specialize in *live rock* extraction. The remainder is concerned with live material collection. Their present area of live collection is in the qoliqoli of Naviti Island but may be expanded to include Nadi Waters and the Mamanuca areas (see Fig. 14).

Live material from their business in Tonga and from other parts of the South Pacific are re-exported through Fiji. The also deal in both wild and hatchery bred *Tridacna* clams.

The live rock curing facility is unique in its design and automation The water is circulated through a filters and a protein skimmer. It continuously provides spray over troughs that hold the rocks. and has a capacity of 12-14 tons during the curing process. It has a 3400 l. reservoir which is refilled weekly.

3.1.4 Waterlife, Fiji Ltd.

The proprietors are Peter Savona and Marika K. Ralovo. Their holding facility is being constructed in Wailada. They have a 4500 l. coral holding facility and an 8000 l. *live rock* holding area. They also have a 12,000 l. fish holding system. Their collection areas are the qoliqoli's of Suvavou and Muaivuso. This operation exports *live rock,* fish and coral.

3.1.5 Aquarium Fish (Fiji) Limited

The proprietor is Tony Nahacky in partnership with Michael Thoms. Aquarium Fish Fiji, which has been in operation for fifteen years, is located in Deuba. Aquarium Fish Fiji has seven full-time employees. In addition there are 10 contracted collectors who supply aquarium fish and a range of invertebrates. Aquarium Fish collects from the Beqa, Yanuca and Deuba waters.

Aquarium Fish Fiji currently exports live aquarium fish and a small range of invertebrate species including non-CITES corals. The company is in the process of expanding it facilities to hold a greater range of live corals. The company has Fisheries Department permission to export live rock in addition to fish and corals.

Their holding system, which is 8,000l capacity, is being expanded to 12,000. The system utilises UV filtration, protein skimmers, mechanical filtration, carbon filtration, and biological filtration with drip systems.

3.2 *Live Rock* extraction (Figs 2-4a-h)

All of the companies involved in the live animal export also export *live rock*. As with the collection of live reef animals, the extraction of live *rock* is contracted to the custodians of the qoliqoli. A license holder represents the team who are trained in the removal of the reef rock. The quantity of rock required is specified daily. It is purchased by the kilogram from the collectors minus any material that is rejected as unsuitable.

Collection of *live rock* is from the reef flat where the material is found around the edges of the reef patches with in the shallow lagoonal water or along the outer algal flat. The removal strategy depends on the nature of the reef flat where both abundance and ease of extraction are considered.

The process involves the removal of blocks of rock with a diameter on the order of 10-20cm. The rock is chosen on the basis of the presence of the pink to dark purple coralline algae on its surface or within its cavities. The rock is removed using iron bars, which chip it from the reef. It is stockpiled and then loaded on a bamboo *bilibili* raft for transport ashore.

Currently there are two main strategies employed. The first occurring Koroniuniu Reef adjacent Malomalo Village (Fig 1a-h) and Vatumalawa Reef adjacent Komave Village (Fig. 4a-c) where the rock is extracted from the shore to the outer algal flat, progressively and systematically along the length of a portion of the qoliqoli. The second is to confine the collection to the seaward edge of the inshore lagoon of Oria Reef adjoining Vatukarasa Village and on to the outer algal flat on Navoto Reef adjacent Sovi Bay (Fig 3a-h). Collection is preferred at mid-tide for the ease of transport of the reef rock back to shore by *bilibili* raft. The rock is piled inshore for an initial cleaning and placed in plastic bins for transport either to the airport directly or to the holding facility where the rock is cleaned and cured to varying degrees depending on the company involved.

Once removed from the reef flat, there are two different strategies of trans-shipment employed. One is the cleaning of the rock in the near-shore shallow water and the weighing and packaging of the material on the beach for direct shipment to the airport. The other is to collect the rock with some cleaning on-site and transport it to a holding facility where further cleaning occurs and a process called *curing* is employed. *Cured* rock is material which has been placed in a holding facility where it is kept moist by a fine spray of seawater. The objective is to keep the coralline algae alive while the less hardy organisms die and are washed from the rock by the water spray. The product is considered of a much higher quality as it is less likely to foul the aquarium system. Because of the variety of organisms which may be associated with the *live rock*, it is important that any mortality associated with the rock occur outside of the tank. Not to do this may severely affect the water quality in the tank. Rock, which is shipped from Fiji directly from the beach, will have to be cleaned or cured to some degree before it enters the intended tank. In this case, this task is left to the wholesaler or consumer and as such the rock is considered of an inferior quality.

As this is a common village resource, the labour for *live rock* collection is drawn from a number of families who alternate in the work force, these are trained personnel are involved. Reliance on subsistent fishing utilizes the collection areas, as well as, other parts of the qoliqoli or adjacent ones.

The controversy over whether to cure the rock or not, conditions the way the respective companies conducts their post-collection process. South Seas Export (Fig 4a-c) feels that it is best to get the

product to market as quickly as possible after collection so that the material is collected prior to the scheduled flights. They claim that the cleaning shortly after collection in the shallow water of the reef returns some of the marine organisms to the reef and, at least, unwanted biomass, which will be eaten or degraded. The return of fauna from the rock to the reef is thought to be of dubious value as few organisms are likely to survive. This is because sessile or attached organisms are unable to reattach. The worms are unlikely to survive as they mature in the protection of the habitat and become easily predated when removed. Mobile invertebrates such as echinoderms and small molluscs would live if not damaged.

The lack of facilities which require extra staff give them a financial advantage over those who *cure* their product. The other companies engage in cleaning at a holding facility and *curing* to various degrees. They claim that this is value added and gives Fiji a good reputation for the production of a quality product. Within the last year, the price of the live rock in the United States from Fiji has declined by more than 50%. This is due to the large amount of product being exported at competitive pricing. The beach shipped rock by South Seas Export has allowed the lowest price structure.

An additional source of *live rock* is being investigated by Aquarium Fish Fiji in the Deuba-Beqa area. Unlike the reef flat source, this material is located at a depth of approximately 10 metres. It accumulates in the grooves of the reef. Because wave action constantly moves these broken dead corals, there is little surface colonization by other organisms. Its loose, semi-mobile nature makes it unsuitable as a fish habitat. Its removal would require underwater breathing apparatus. The resource would have to be subject to an environmental impact assessment.

Figure 2: *Live Rock* collecting operation adjacent Malomalo Village.

a) The shallow inner lagoon showing the nature of the reef which has served as a source of material for four years. The *live rock* is extracted from the edges of the coral patches.

b) The work force removing the coral from the reef flat. The material is stockpiled inshore before removal from the water.

c) *Live rock* being transported inshore by bamboo *bilibili* raft at low tide.

d) Colonisation of the macro-algaes *Turbinaria ornatus* and *Sargassum cristafolium*. The algaes are heavily fouled by epiphytic growth.

e) Transport of the reef rock ashore.

f) A typical site where the *live rock* is extracted by progressively prying away of the reef edge.

g) Loading and transport of the rock to the holding facility in Nadi.

h) Appearance of a reef knoll subjected to rock removal.

Figure 3: *Live Rock* collecting operation adjacent Vatukarasa Village.

a) The nature of the reef flat from which the *live rock* is taken. The area is largely inter-tidal with only small shallow lagoons.

b) The appearance of the *live rock* bound for an aquarium tank in the United States. The encrusting purple material is the coralline algae.

c) *Live rock* showing the turfed and macro-algaes on the rock. It is this material that is removed as part of the curing process.

d) A trained collector looks for good quality material prior to removal.

e) Collectors ferry the material ashore via *bilibili* raft.

f) *Live rock* in the holding/curing facility at Walt Smith International's warehouse.

g) *Live rock* being cleaned of the larger organisms prior to curing.

h) *PREMIUM FIJI AQUARIUM ROCK* being shipped to the United States by Walt Smith International.

Figure 4: *Live Rock* collection – Komave Village for South Seas Export Ltd. (a-c)
Muaivuso Village adjacent to Suva Harbour for Waterlife Ltd. (d-g)

a) The reef is characterised by shallow depressions with in a rubble filled surface that is exposed intertidally.

b) Komave villager cleans the rock in the shallow nearshore channel.

c) Collectors weigh and pack the material on the beach for trans-shipment to Nadi and the United States.

d) A sample of rock taken from the permanently subtidal area in Suva Harbour. The reef rock is of coral/algal origin being encrusted with the purple coralline algae.

e) The nature of the subtidal area with samples of the rock in the foreground.

f) Dense stands of *Porites cylindrica* adjacent Muaivuso Village. The dead base of this coral is a coralline alga incrusted. To obtain the algal covered material, the living coral would have to be removed.

g) An example of the dead center of the branching *Porites* colony where the live rock is found.

3.3 The Curio Coral Trade

Described as decorative, ornamental or curio coral, the product is the skeleton of hard coral or related organisms with a hard skeleton. It is collected live, usually as a whole colony, and sold in bulk as a sun-dried item. Value may be added by bleaching or dyeing the coral as well as supplying the packaging required for the retail market prior to dispatch overseas.

The coral collected are the reef building, hard coral of the Order *Scleractinia* and predominate the relatively shallow water of the reef (intertidal to 3m). Whole colonies are generally collected. Those specimens preferred because of their particular skeletal architecture are usually of the fast growing species of the genus *Acropora.* Other genera are taken and one of the most popular is that of *Pocillopora* and the pipe organ coral, *Tubipora musica*, of the Class Alcyonacea. This latter species is not a true hard coral but possesses a hard red calcareous skeleton. Black coral (Antipatharia) was collected from the Beqa Lagoon and used to make jewelry during the mid-1980's to 1990 but this has now ceased. Other corals which have been used in the ornamental coral trade but not collected in Fiji are the blue corals Heliopora (Order Coenthecalia) which occur only in Rotuma, though with a wide range outside of Fiji. Other semi-precious corals comprise the small but brightly coloured *Stylasterine* corals or lace corals of the Class Hydrozoa. It is likely that there are deep-water corals present in Fijian waters such as those collected at depth off Hawaii and used for jewelry.

Two companies are engaged in the collection of curio coral. These are Seaking Trading Co. and Acropora International Ltd.

3.3.1 Seaking Trading Co. (Fig 5a-h; 6b-c,g)

This was the first company to commercially remove coral for export in Fiji and began operation in 1984. The history of the company has been intermittent with their operation beginning in Bau Waters subsequently moving to the central-east coast at Dawasamu and now operating adjacent Viti Levu Bay on the northeast coast.

The company is owned and managed by Mike and Kathy Thoms. They employ 2 in administrative work and 8 in processing. Their offices are located in Wailada, Lami with a warehouse is in Nausori for processing the coral.

They have the first facility which is attempting to add value to the coral pieces by preparing them for the retail market (bleaching, dyeing, retail packaging). They employ several villages (30 persons) near Viti Levu Bay to harvest the coral, which are paid for by the piece. They use a truck and employ a driver.

Figure 5: Curio coral harvest adjacent Viti Levu Bay by Seaking Trading Co.

a) Luxuriant coral on Naba Reef which is one of the sites of collection.

b) Reef slope on Naba Reef showing that the proliferation of coral is confined to the reef flat with the surrounding steep slope, hosting little coral.

c) Stockpile of 23,000 colonies of *Pocillopora damicornis* and *Pocillopora verrucosa.*

d) Tabulate *Acropora* colonies in the lower left with piles of branching colonies of *Acropora formosa* (upper center) and *Pocillopora spp.* (right and background).

e) Area of previous collection shows the regrowth of the remaining colonies.

f) Cleaning and bleaching of coral specimens prior to packaging.

g) Cleaning of the pipe organ coral, *Tubipora musica.*

h) Coral specimens ready for dispatch to the United States.

3.3.2 Acropora International Ltd. (Fig. 6a,d-f)

This company began operation in 1992. Formerly operating in the curio and coral manufacturing trade in New Caledonia, the company moved its operation to Fiji. This was in response to the closing of their coral lease in which material for manufactured coral products were obtained. An initial partnership with Seaking Trading, FTIB concessions, and an attractive local wage structure were deciding elements in their relocation here.

Claude Barbera and his assistant Ethel run the company from their office and warehouse in the Kalabo Industrial Estate located in Nasinu. Their collecting area is Bau Waters with their landing facility in Naimasimasi, Vugalei, Verata. They also make limited decorative objects such as sphere's and lamp bases by fashioning coral heads with a lathe.

Naisomua and Naiborebore Village collects the coral for the company, drying and packaging it near Naimasimasi village.

3.3.3 Collection and Trans-shipment

The Fiji companies receive orders from their overseas wholesalers for particular species or groups of species with a particular growth form. As with the *live coral* trade, the companies subcontract the collection to the villages who collect from their qoliqoli. The village collectors, who have been trained in the species recognition, are requested to fill the order. Coral is gathered by divers using prying bars and placed in boats. Extra material for popular classes of product is also obtained. The material is taken ashore and dried in the open sun. Waste is minimised by the careful selection and handling of the material from its field collection to drying. A broken or damaged piece becomes a non-saleable item.

After drying they are sorted into groups based on colonial form and wrapped securely with newspaper. The corals are then boxed in heavy wooden crates and loaded into an on-site container and taken to the wharf for overseas dispatch. The majority of the consignments are sent to the United States though countries in Europe are now requiring material. Within the importing country, the corals are sent to the wholesaler's warehouse from which the material is distributed to various locations.

Whether purchased for the aquarium or tourist curio, its life depends on the care taken of the specimen. It is non-degradable and if dirty, can be recleaned by simple washing or bleaching. In an aquarium the carbonate skeleton is supposed to assist in the conditioning of the seawater but is now being largely superceded by *live rock* which appears more natural with its living surface of coralline and macro-alga and is less likely to be affected by spurious and unsightly fouling.

Figure 6: Coral collected for curio, medical and septic systems

a) Coral is being dried and packaged for container shipment.

b) Branching *Acropora nobilis* drying.

c) Solitary corals of the genera *Fungia* and *Herpetolitha* ready for packaging.

d) Collection of tabulate corals *Acropora hyacinthus* by Acropora Int'l in Kabuna waters.

e) Removal of coral from its reef substrate.

f) The coral *Acropora palifera* stockpiled under water for subsequent collection.

g) The genus *Goniopora* utilised by the medical profession for bone reconstruction. Specimens show where plug samples were taken for analysis.

h) Piles of *Porites* colonies stacked along the roadside. Collected from the Suva Barrier Reef, they are sold to building contractors for use in septic system soakage pits.

3.4 Other Coral Derived Products

3.4.1 Live Sand

Live sand is sand composed of reef components. Chemically, it is calcium carbonate being largely the erosional material from the breakdown of coral skeletons, shells, calcareous algaes and coralline algal accretions. It is considered *live* due to the interstitial fauna such as worms and small crustacea. Also represented in the sand by their symmetrical skeletal shells, foraminifera may be living subtidally. The presence of the red skeletons of the pipe organ coral makes for an attractive addition to the white calcareous material.

The sand cycle (Fig, 7) below indicates the sources of input into the varied composition of sand. Generally, the amount of sand that is available within a reef system is abundant. It is continuously produced by erosional forces and the natural attrition of the skeletal components of the reef fauna. The impacts perceived from the removal of large quantities of sand such as in dredging or beach restoration can create further erosion or problems of turbidity. The extraction of sand for the aquarium trade is not on that magnitude and, generally, would be considered making use of an abundant resource. Problems with the extraction may occur if an area of particularly attractive sand is taken from a resort location or in an area frequented by tourists. The quantity would have to be substantial to be considered a problem. At this stage, insufficient sand is being exported to warrant concern. As with other aquarium products, notice is to be given to the Fisheries Division for their assessment prior to removal.

The procedure for acquiring permits to export sand is uncertain. The Fisheries Division is considered the controlling agency, as there is an infaunal or burrowing component to sand collected inter- and subtidally. They have done surveys and issued permits for extraction.

Fiji Industries Ltd. mines many thousand tons per year of carbonate sand from the lee side of Nucobuco Reef (see next section). This relic material has been deposited during the period of the Holocene high sea level (3-5000 yrs. Bp.).

Figure 7: The Sand Cycle with Sources of Carbonate Skeletal Material and Erosional Forces.

3.4.2 Lime

The burning or heating of coral releases carbon dioxide to create calcium oxide or lime. This is used in a variety of ways. The tradition in Indonesia, Papua New Guinea, Palau, and the Federated States of Micronesia is to chew the lime with betel nut as a social and herbal drug. It has been calculated that consumption in Yap is 130 tons a year (Maragos, 1990). In Malaysia and Indonesia, coral rock is cooked in kilns to produce a lime for a plaster that is applied to the bottoms of boats as an antifouling barrier. Subfossil corals are mined from Moreton Bay, Australia as a carbonate source for the production of cement (Qld. Cement and Lime Co., 1964). Sand mining by Fiji Industries in Suva Harbour is for the purpose of providing lime for the cement and agricultural industry. The deposit that is being mined is on the back reef area of Nukubuco Reef, along the southeastern margin of Laucala Bay. An environmental impact assessment for this operation has been carried out (Penn, 1982, 1983).

3.4.3 Septic system drains (Fig. 6h)

Since 1965, live, boulder-like colonies of the genus *Porites* have been taken from sites in Suva Harbour. Formerly, the material was removed from the inshore areas of Lami Reef. Now exhausted, this material is collected from Suva Reef where the reef flat and adjacent shallow waters are being denuded of this long-lived species. It is sold along the roadside on Queens Rd. A pile of coral sells for $40. An average sized coral is 60 years old. Far from sustainable, this practice is equivalent to the mining of the living resource which will eventually exhaust supply. The boulder-like coral is used in the construction of drains and soakage pits for septic tanks as required by the Suva City Council regulations. Unfortunately, this type of exploitation is based on the mis-assumption that the material is uniquely suited to the application, whereby the smell of the wastewater overflow from sewage systems will be removed by the presence of the coral. The notion that only coral will carry out this function is a fallacy as any material, which would allow the growth of bacteria on a large surface area, would be suitable. It is a mistake to think that the porous nature of the skeleton is effective. Once saturated with water it is relatively impermeable. Elsewhere course gravel is used. This material is used because 1) it was available where suitable alternatives were harder to obtain, and 2) there is a misconception that coral is the most suitable.

The ecological consequences of this extraction will never be known except through speculation. These colonies, in most instances, form the basis for the patch reefs in the sandy, back reef areas. With their removal the most stable portion of the patch reef structure is lost and the remainder more subject to decimation by storm action.

Curiously, this material falls under the jurisdiction of the Lands Department who issues a mining lease under the pretence that the material is dead coral. Both the Fisheries Division and the Lands Department know that this is **not** the mining of dead material. The extraction of living coral, categorically, should fall under the management of the Fisheries Department guidelines. The present arrangement is based on recognition that Suvavou has a right to utilize their qoliqoli resource. As it is considered largely mineral, the Lands Department officiates the permit though no environmental impact assessment has been carried out. The size of the colonies indicates an age class (40-80 years) which should be considered unsustainable as the resource is being utilised faster than it can be restored through recruitment . The broader consequences of habitat removal and fisheries impact of this practice are unclear.

It is apparent that the qoliqoli has become degraded by the development of Suva and the Port. There is heavy usage of the reefs in the Suva area, which supports subsistence, artisanal and recreational fishers and general users from outside of the village. As a result, village protection of the fishery has become passive.

The South Pacific Regional Environment Programme strongly recommends against the use of living material for construction applications because of the detriment to the coral reef and the fact that other inorganic alternative materials are available which would preclude detriment to the coral reef system.

3.4.4 Medical Use of Coral

The use of processed coral skeleton to assist in the repair of bones severely damaged by trauma has been in use since 1982 (Sartorius et al. 1986; Hodgson, 1989). It is a valuable medical tool which provides a ready material for bone replacement in the event that a portion of the injured or diseased bone is lost. This prevents the need for the transplantation of healthy bone, which entails additional surgery. New bone readily grows over the coral material and is not recognised as being foreign by the human immune system.

The corals in demand are *Goniopora* and *Alveopora*. The latter genus is used for dental and facial reconstruction. There is a patent on the processing of the material. Information on market demand is not available but the quality of the product precludes the use of many of the specimens. Seaking Trading Co. periodically supplies a California pharmaceutical firm with whole colonies. The global trade in this coral peaked in 1992 at 26t, but declined to extremely low levels since (Green and Shirley 1999).

3.4.5 Research

The amount of coral removed for scientific purposes is usually small. Such collections are required to more fully understand the coral reef ecosystem. This knowledge contributes to the formulation of conservation strategies. A reference collection has been compiled at the Marine Studies Programme of the University of the South Pacific. This is essential for reef survey work such as environmental impact assessments, comparison with corals in other parts of the Pacific and Indian Oceans, and as resource material for students.

4.0 History and Current International Trends

The world market for ornamental corals increased rapidly in the 1970s and 1980s and has been subject to wide fluctuations since then. In 1990, the international coral trade used 1.2 to 1.5 million pieces of ornamental coral weighing 500 tonnes. The USA is the main consumer, accounting for 70%-90% of the use. Other significant coral importers are European countries and Japan. A record international trade of 1456 tonnes per year in 1988 has risen from an annual average of 200 tonnes in the 1960s. Indonesia and Haiti are the main suppliers, with the Philippines, Singapore, Sri Lanka and Taiwan prominent. The USA imported 480 tonnes in 1988 from Indonesia (Wood and Wells, 1988; Wells and Wood, 1989).

The Philippines was one of the main suppliers, despite legislation since 1977 banning collection and export (apart from brief periods in 1986 and 1992 when the ban was temporarily lifted). Supplies from the Philippines continue to be available through the use of forged permits (Mulliken and Nash,

1993). In 1988, USA illegally imported about 600 tonnes from the Philippines, violating both Philippine law and the Lacey Act of the USA which forbids the import of illegally procured goods. By 1993, fewer than 500 pieces of coral were exported from that country.

Concurrent with the reduction in trade from the Philippines, exports from Indonesia rose and by the early 1990s it became the world's primary supplier of coral pieces. By 1993, Indonesia exported about 83% and 92% of the trade in raw and live corals respectively. During the mid-1990s, total Indonesian exports of corals were around 1 million pieces annually with 84% of these going to the USA and Japan. Between 1985 and 1995, 43% of exports were of live corals (eg. Euphyllia, Goniopora and Catalaphyllia). There has been a trend towards an increasing proportion of live exports and by 1995, around 80% of the corals imported into the USA from Indonesia were alive. (Bentley, 1998)

The coral trade varies from place to place. In the Philippines, over 30 species are collected , while in Fiji, 56 species are utilised. These industries are export oriented, servicing mainly the United States market. Most of the corals taken have a rapid growth rate. In Australia, the industry is quite different, with the harvest largely of the genus *Pocillopora* and the market almost exclusively domestic. The USA and European countries are the major markets for live corals. 345,000 pieces of live coral were imported in 1991 as compared with 40,000 pieces in 1988. Live coral now makes up one third of the total USA coral imports (Mulliken and Nash, 1993).

4.1 Fiji and the Pacific Islands

Fiji is the major exporter of live coral in the Pacific Is. with contributions from Tonga, Vanuatu and the Solomon Is. Fiji is the only regular supplier of curio coral from the Pacific. The fishery is under review by the Fisheries Division in which they are seeking, through prohibition and limitation, to confine the harvest to sustainable levels.

Fiji exported over 12,000 pieces of live coral in 1991 with the figure approaching 500,000 in the last two years (478,636in 1997: 4976,732 in 1998). Projected exports for the year 2,000 are in excess of 600,000 pieces. At the current rate of export, this figure will be surpassed.

New Caledonia, through the export of brain coral (Faviidae), was a major supplier in the late 1980s. These were exported as value-added objects through lathe worked coral lamp bases and decorative shapes. The export of this material dropped from 120 tonnes in 1989 to zero in 1991, due to the business moving to Fiji.

Western Samoa exported eight tonnes of coral for medical purposes to the US in 1989 but the export of coral harvesting is now prohibited. Similarly, Vanuatu exported coral in 1991 and 1992. A small amount of *Heliopora* was exported from Kiribati to the US through the Fijian company Seaking Trading Co. The Marshall Islands exported 18 tonnes in 1990 and the Solomon's six tonnes to the US in 1991. Tonga attempted to export coral for medical purposes but the government banned all harvest in late 1993. The Federated States of Micronesia have exported ornamental coral.

Comparison of the industry with that of Australia is illustrative of the way in which the industry may differ. In Australia a decade ago, 45 tons of coral was being harvested annually (Oliver et al., 1985). The coral is sold domestically as tourist curios or as specimens for marine aquaria. Coral exports were less than 150 kg per year. Collecting areas are designated as 400m segments of the reef front. There is state and federal regulation. Further regulation is in effect if collection is to be made within the Great Barrier Reef Marine Park (GBRPA). In 1983, there were 12 active collectors of which two accounted for 60% of the market. These were principally harvesting *Pocillopora damicornis* which comprises 70% of the harvest.

Two other corals, the *Fungia* (mushroom coral) and the branching *Acropora* made up 8% and 6%, respectively. Sustainability for perpetuity is the policy adopted by the GBRPA. The Great Barrier Reef due to its distance from the mainland is, in general terms, one of the least exploited of reefs in the Indo-pacific region.

Where there are coral reefs, there is often demand for coral souvenirs for the tourist industry. With prohibition of local curio harvest, importation may occur. With the coral banned for collection in Hawaii, supplies may come from the Philippines and Indonesia. The same occurs in Florida where coral extraction is prohibited but the demand supplied by S.E. Asia, as well as Fiji.

The export of decorative coral began in 1984 and for 8 years only Seaking Trading Co., was operating in Fiji. What began as 12 containers per year in 1985, increased to 17 by 1987 (Viala, 1988). By 1991, the export had grown to 49 containers per year. In that year, 70,895 pieces were exported to the USA from Fiji. The harvest for a three-year period of 1985-1988 was 152,114 pieces. The current yearly harvest is on the order of 125,000 pieces per year and has the potential to double. In 1993, 36,424 kg was declared for export. In 1994, 54,430 kg of coral was exported. A container is equivalent to one to two thousand pieces of coral, depending on the size of the specimens taken. This may go to 6000 for a consignment of small specimens. The majority of Fiji's exports are destined for the United States.

Table 1. Number of pieces of curio coral exported between 1985-'89 and in weight in metric tons during 1990-'92 and the value (FJD'000). Note: The exported weights for the years 1990-1992 refer to "Corals and all others", including rocks and other materials. Curio coral is likely to be only a small portion of this (FFA, 1992).

1985		1986		1987		1988	
Pieces	Value	Pieces	Value	Pieces	Value	Pieces	Value
3,243 (est.)	12.38	30,789 (est.)	117.34	56,186 (est.)	136.36	61,896 (est.)	159.28

1989		1990		1991		1992	
Pieces	Value	Weight	Value	Weight	Value	Weight	Value
101,200 (est.)	253.0 (est.)	1,008.42	1619.1	315.21	238.30	268.7	316.20

Table 2: Countries to which Fiji exported coral to in 1993-94*

Country	Volume Kg			
	1993	1994*	Total	% Total export
United States	34,284	54,274	88,558	97.4%
New Zealand	2,138	156	2,294	2.5%
Canada	2			-

* The 1994 figures account for only eleven months of the year and comprise mainly *live rock.*

Several factors make Fiji ideal for the export of live coral. The dual tenure system where by coastal villages manage their fisheries resources of their customary reef areas. Adequate infrastructure which allows transport and holding of live product. The availability of airline services that deliver the live specimens in a timely manner (<16hrs.). Good shipping services for the transport of container packed curio coral.

Export of coral products are likely to increase for several reasons. There are no limits placed on the export of material. The markets for all coral products are expanding both in terms of popularity in existing markets and new markets are being attracted. Many of the coastal villages are eager for the income derived from the new resource.

5.0 CURRENT DEBATE AND CONTENTIOUS ISSUES

Discussion of coral harvesting often provokes debate as to whether the benefits outweigh the disadvantages. The discussion often applies the general concepts of ecological theory to particular situations where reef products are being removed. The love of the conceptual image of a luxuriant reef being destroyed by commercial interests is emotive but is not in keeping with the realities of the commercial operations or the dynamics of the natural cycles on the coral reef. With the recognition of the potential benefit of the new fisheries, the real issue becomes a question of management of the reef collection and the limits that should be placed on it. Important is the monitoring of the collection operation and the identification of the concerns over time.

The importance of coral reefs in Fiji and most of the Pacific Islands is as a basis for a subsistence fishery's and is essential to the well being of the coastal people. Additionally, artisanal fisheries provide a much-needed source of monetary income. With the tremendous increase in the popularity of coral reef products overseas, a new opportunity has appeared which may add to the bounty of the traditional coastal fisheries. The question that is central to this new opportunity is whether it may negatively affect existing fisheries or conflict with other opportunities such as tourism. Conservation considerations that repeatedly call for caution when dealing with the coral reef ecosystem are often the result of our incomplete understanding of the status of the items collected and the precise impacts to the rest of the system. Ill-considered caution may negate opportunity which may yield substantial benefits to village life. Sharing these concerns in a more intimate way are the people who have and continue to depend upon these reefs for a good portion of their livelihood and have for generations. The qoliqoli custodians have always fished their reefs and taken advantage of the natural cycles when abundance occurred. With this new fishery, the decision to pursue the financial opportunity is made with the confidence that they will monitor the resource and deal with the problems, if they arise. The rational is based in the understanding that the coral reef has the ability to restore itself after being subjected to devastating events such as floods or cyclones. If the new enterprise proves too destructive then ceasing it will allow the reef to regain its former balance. Immediate monetary return for the reef products is a persuasive incentive in a cash poor environment where unemployment is high. The need to pay school fees and a desire for retail items, promote a willingness to engage in an occupation, which seems to have little immediate consequence.

5.1 Ecological Consequences of Commercial Exploitation

There is general agreement that the benefits to be derived from the collection operations must be weighed against the perceived disruption to the reef ecosystem. Statements of caution such as "The profit derived from coral extraction, whether for the curio or aquarium trade or for medical material, may be insignificant when compared to the loss to fisheries or tourism (Wells et al. 1994)", provide doubt that the initial benefits of employment and income may not equate to long term costs. This premise is a conservative approach, which neglects the detailed assessment of the varied products being taken from the reef environment and more importantly the varied circumstances and environments. Its underlying tenet is the *Precautionary Principle*, whereby unless most aspects of coral reef relationships are known it is better to not engage in enterprises that have disruptive aspects with the potential for negative consequences albeit unknown. If caution can be flawed, it is that this statement does not reflect the realization that the nature of the consequences are unclear. Since some negative consequences maybe acceptable given the reward of employment, it may be worth trialing an activity. If it proves unacceptable, in balance, the custodians can cease it. The capability of the reef to recover from natural disasters provides certainty that it will recover from collection. In some cases of live rock extraction, the topography of the reef will remain altered but recolonisation by reef organisms will occur.

The basic constraint to providing precise answers to resolve this cost benefit relationship is the lack of understanding the reef dynamics of recruitment and the inter-dependencies of coral reef life. Though there are volumes devoted to coral reef science, the variability within reefs precludes the uniform application of theory. It is central to the problem that each reef is different by virtue of its morphology, proximity to other reefs and oceanic influence. Also important are river effects and user pressures such as fishing and tourism. Depending on the type of extraction, coral reefs vary as to the amount and type of living material and the ability of natural abundance and recruitment to accommodate collection.

Concern is expressed that the removal of coral and coral rock is the removal of habitat. Habitat relief is considered a principal and vital component of a thriving reef. Its function is shelter for fish and other marine creatures and, more importantly, their contribution to the food production. Reduction in coral cover translates directly into a reduction in the abundance of fish in the local fishery. Carpenter et al. (1981) found that, in the Philippines, there were more fish where there was greater cover of live stony coral. Fish have been reportedly less abundant in areas where coral harvest had been taking place due to the general disruption of the biotope (Joannot pers. comm.). Dulvy et al. (1995) found that the removal of live coral cover and rugosity or the reduction in topographic relief lead to both a reduction in fish abundance and diversity. Other studies confirm this relationship (Luckhurst and Luckhurst, 1978; Bell and Galzin, 1984; Sano et al., 1984; Bouchon-Navaro et al., 1985).

It is important to more closely define the above considerations. Firstly, these remarks are more applicable to the curio coral trade where whole colonies of a wide range of sizes are sought. The comment by Joannot is based on perception rather than data and does not define the nature of the reef, account for their variability, or specify the type of fish being considered. For example, both fish and coral respond to water quality. Proximity to river and variation in outflow, determines both the amount of coral and the types of fish. Herbivorous fish thrive in the areas of fleshy algal growth which has also been responsible for the death of coral (Lovell, 1997).

5.1.1 Live coral

Live coral collection includes a wide variety of attached reef organisms. Though the biology of many of the plants and animals is categorically known, the impact of the removal of these organisms is less clear. Due to the abundance of many of the items collected and the size categories sought, intuitively, there seems to be fewer potential problems. Confined to small colonies or portions of colonies, the prospect of habitat removal is minimised. The material is treated carefully and every attempt is made to keep it alive. There is always the prospect of a reduction or depletion of a species population from a particular collecting area. For many species it seems unlikely as the size sought leave an abundance of the larger organisms. Also the requirement for the species is unlikely to supercede the natural recruitment, given the size of the qoliqoli. Naviti Island, Yasawa is an example where the qoliqoli consist of large areas of remote reef. Here the conflicts of tourism and subsistence fishing are not an issue.

5.1.2 *Live Rock*

When *live rock* extraction is confined to the outer algal reef crest, as at Vatukarasa Village, the removal of coral cover is minimal (Fig. 3). The material being removed is a combination of algal origin and, most probably, relic reef material which was deposited during an earlier period of 100's to 1,000's of years before present and may predate the Holocene high sea-level (20,000 BP). The zone where removal takes place is uniform in appearance, being the result of periodic tidal and wave exposure. Removal of *live rock* leaves shallow pools in the area, which increases habitat relief and the available amount of intertidal ponded water. Microhabitats are important for sheltering juvenile fishes and other organisms are protected from desiccation and predation (Shulman, 1984; Dulvy et al. 1995). Whether this results in an increased biodiversity would be determined through monitoring. Monitoring is also important in assessing the potential for erosional events which result from the digging out of the reef surface. At first inspection, this seems unlikely.

Live rock removal is not confined to the outer algal crest in some operations. At both Komave and Malomalo villages, the entire reef flat from the outer crest to inshore is utilised for collection. In the Komave situation, the reef flat has little relief, without a prominent lagoon. It's proximity to periodic river out flow, has naturally created a reef whereby coral cover is minimal. A periodic cycle of death through flooding and subsequent deposition by wave action has led to a reef flat which has little topographic variability being largely composed of coral rubble. Harvest of the *live rock* in this area has little effect on the sparse coral growth and increases the amount of intertidal ponded water.

By contrast, the Malomalo situation is where the inner lagoon area has been fully utilised in the collection of *live rock,* resulting in the inundation of the coral fauna. The peripheral portions of coral patches are being progressively removed for aquarium habitat. This is a decision to treat a portion of the qoliqoli in a manner where an area is devoted to the removal of a single product with no concern for effect on other fisheries. There is conflicting reports as to the effect on the fishing in the area. Some feel that the disruption of the reef flat and subsequent algal predominance has caused a decline in the fishery. A competing opinion is that the opening up of the habitat and the presence of new algal growth have increased the amount of fish available, particularly for netting. This is contrary to the published work in the introduction to this section.

5.1.3 Curio Specimens

Inspection of reef areas, subject to short term (1-2 yrs.) and four years collection of coral, have proved difficult to detect any change which has occurred at the collection sites. This is for several reasons. The collection is not managed so that the quantity of material taken from a particular reef is not known. At least in the initial stages, the abundance of material doesn't require a collection strategy and is done in an *ad hoc* manner. As a result, it is difficult to inspect areas with an unknown collection history. This coupled with the biological variability normally encountered on coral reefs, results in the discerning the effects of collection being difficult to assess.

With the removal of the monopolising (*Acropora nobilis)* or expansive coral colonies (Acropora hyacinthus), other reef organisms colonize the newly available area. For all appearances, the reef continues to have an appearance of luxuriance with high living cover. The collection of curio specimens has given rise to most of the complaints. It has the longest period of operation, and potentially, represents the largest export of bulk coral material. The visual presence of the material being dried or stored has an appearance of substantial reef removal.

5.2 Issues and observation

Common to all types of collection is the consideration of waste or inappropriate collecting and the pursuit of efficiency. Much of this has to do with the managing the business in a "best practice" sense. The consideration of waste is something that is always addressed by the operator and every attempt is made to minimise it. Waste is loss of profits. Unfortunately, the selection process is often been perceived as one of waste, conducted by collectors who take material which is of no use, due to size or careless handling. Another complaint against the industry is that each piece of coral that reaches the foreign consumer represents many that were damaged and discarded along the route to the retailer. The delicate nature the coral makes them prone breakage and only intact or uninjured corals are acceptable in the foreign markets. Also, careless collecting can also damage other non-target species. Organisms, peripheral to the coral being removed, can be adversely affected.

Commercially, it is in the interest of the collector to see that the product gets to market without damage. Collectors are trained to select only saleable material. To a large extent, suppliers provide specimens to order. Observation of the field techniques revealed that, although peripheral material may be damaged, it

is generally not, as the most efficient way to collect the coral so to lift it after detachment and swim it to the boat or stockpile it in a sandy patch for subsequent collection.

Instances of inefficiencies or waste were observed with respect to the curio trade.

1) Several piles of coral skeletons have been discarded on the bank of the Navulaoa River landing near Waikete Rd. by Acropora International Ltd.

2) Seaking Trading Co. has stockpiled a very large quantity of coral ($378m^3$) Navuniivi Village adjacent Viti Levu Bay. The collecting is far in excess of that with which the business can efficiently process. Much of the material damaged or not of marketable sizes. The coral was collected six months prior but remained stored in an unprotected area, being subject to the degrading effects of weather and soiling.

Some concern as to the sustainability are based on the variability in growth rate. As well, the occupation of space in a reef community is fundamental to its success. Corals can take several years to decades to reach an equilibrium, which can be called a mature community (Grigg and Maragos, 1974; Pearson, 1981). "Any long range management schemes for the harvesting of corals from specific reef sites must account for the normally slow rate of colonisation and recovery of coral colonies." (Wells, et al. 1994). Both of the above considerations and the fact that corals are easily accessible for collection due to their sessile, shallow existence, make them especially prone to over-exploitation. When two reefs in the Philippines were compared, the one on which collection had occurred, hosted smaller and fewer corals than on the adjacent unexploited reef. Selective population changes resulted from commercial collection. Six of the collected species were reduced in terms of colony density and percentage reef cover by 70%. Long term collection of small *Seriatopora* may explain its absence by removal of the mature and reproductive specimens. The same is thought to account for the solitary coral *Fungia* (Ross, 1984).

In New Caledonia, massive corals were harvested and fashioned into various decorative objects. Coral harvesting was allowed on only a single reef. Research on the extraction was conducted by the Noumea Aquarium and as the subject of a post-graduate thesis. Assessment was made of weights, size frequency distributions and other aspects of the exploited population. The maximum sustainable yield was calculated and compared with the amount harvested. On this basis, it was estimated that coral removal was twelve times the sustainable yield (Joannot et al., 1988).

How relevant are these considerations to the management decision for coral collection. Several factors mitigate against the longer term depletion of the resource. As the coral is taken from relatively shallow water, recruitment will occur from adjacent deeper water. Large colonies (>.8m) are not taken which serve as a source of recruitment as do the uncollected reefs up current from the resource. Collection of some colonies such as the tabulate *Acropora* may be considered to be more quickly replaced by coral and other organisms which were being over-topped by the colony's expansive growth. This growth strategy of over-topping secures the colonies position and is particularly effective, given the rapid growth rate of the coral. If a reef is over-collected, ceasing collection should return the luxuriance of coral cover eventually. Monitoring has shown that this is relatively quick (< 3 yrs.) recolonisation in an hospitable environments and a much longer period of time in marginal environments (>10 yrs.) (Tamata and Lovell, 1998)

Clearly, the composition of coral and the nature of the reef can be affected by the removal of coral. It is also true, that in some instances, coral has an astonishing ability to recolonise in the face of the natural disasters and, by extension, has the potential for limited extraction.

6.0 EXPORT STATISTICS

The Fisheries Division collects statistics on reef products that are exported. This is done through a permit system whereby the operator applies for an export permit stating the numbers or the amount of material that is being exported. Under CITES, all hard coral species plus *Tubipora musica* and *Heliopora coerulea* must be itemized on the export form. Additionally for the USA importation a CITES form must be completed for non-CITES organisms which are attached to a rock base. The categories of coral product export are the following:

1. Live coral pieces -- This is the product is used by the aquarium trade. It represents living whole colonies and fragments of a wide range of soft and hard coral. Ocean 2000 Ltd., South Seas Export Ltd., Walt Smith International Ltd. and Waterlife (Fiji) Ltd. export this material.

2. Live giant clams -- These are the small clams (generally <12cm) of the genus *Tridacna.* They are collected both from the wild and obtained from hatchery stock. Ocean 2000 and Walt Smith International are exporters. Other reef plants and animals are collected but clams are the only statistics available.

3. Live Base Rock -- This is the *live rock* material which represents algal covered reef rock. All of the exporters of live coral, export live rock (See section 2).

4. Unworked coral is the hard coral exported by the Curio trade. It is the dried coral skeletons whose only processing after collection is packaging in crates and dispatch by container. Only Acropora International Ltd. produce material in this category. Seaking Trading Co. had exported this material for ten years from 1985.

5. Worked coral – This type of product are coral items in which value is added. Both Acropora Intn'l and Seaking Trading Co produce material in this category. Acropora Intn'l produces coral products which are fashioned through lathe work. All of Seaking Trading Co. export is in this category. Their products are bleached or coloured coral, shrink wrapped with pricing code attached.

6.1 Export statistic problems

Unfortunately, the value of the statistics have been severely diminished through the Fisheries Division practice of including aquarium products collected in other countries as Fiji exports. All live coral and rock statistics are a composite of unknown proportions of material from Tonga, Solomon Islands, Vanuatu and Bali, Indonesia as well as Fiji. Walt Smith Int'l is the only firm currently trans-shipping. With respect to CITES, this practice misrepresents the origins of collection and provides inaccurate documentation that the trans-shipped reef products have come from Fiji. It has the unfortunate effect of crediting Fiji as the source of much more material than is actually the case and obscuring the origin of reef products. Any comparison of exports with other South Pacific countries and, more importantly, globally is skewed. This practice of re-export is common, globally, with 16% of all coral traded re-exported. The USA exported to 19 different nations coral products that originated from 15 others (Green and Shirley, 1999).

More importantly, the number of specimens actually permitted by the Fisheries Division and the numbers actually exported are vastly different. This is due to a convenience in permit application whereby the exporter applies for permits for a quantity well in excess of the species to be sent. The consequences of not having ample permit numbers of any of the consignment species might result in the confiscation of the shipment. To guard against this, a large number of a particular item

is permitted for. This is routinely done as a template with the same large number covering many of the categories. The importing countries such as the United States don't regard the excess permitting as a problem to their system. From an operational point of view, this mechanism has advantages. As much of the shipping is done at night or on the weekend to accommodate the flight schedules, documentation by the Fisheries Division must be pre-arranged to be practical. This caters for the need to send the living organisms as soon as possible after collection, delays in the permit processing or the prospect of not permitting for an adequate number of specimens. The arrangement would be valid, were it not for the recording by the Fisheries Division of the hypothetical maximums as actual data of export. The result of this practice has led to the apparent high numbers being attributed to export from Fiji. The exporters, generally, submit a summary document which details of their exact exports but this hasn't been used in the recording of the fisheries export data. The permit numbers are often 4-10 times the actual exported quantity.

An additional problem is the use of the two databases used by the Fisheries Division . One records exports from the Western Division and the other from companies based in the Eastern Division. If one of the computers is inoperative, the records are placed on the other and has led to confusion of records. Secondly, there has been inadequate back-up and for the years to 1995, the data has been lost.

Confusion has occurred with the assessment of export figures of live coral. The principal error is to combine live rock and live coral exports. The live rock weight is converted to "pieces of live coral " through a conversion factor (200g/coral piece (Green and Shirley, 1999)) or simply considered as live coral weight which vastly inflates the live coral export figure. Live rock is almost wholly a coralline algal concretion of reefal material. It is reef rock saturated with water giving substantial weight. To consider this as coral is naïve, confusing and severely diminishes comparative statistics. This particularly the case for countries who do not export live rock at all. A similar error is to combine the curio coral exports with the live coral which clouds the useful description of these very different enterprises. The combination of curio coral and live coral as a statistic is equally in error. The two trades are very different in the product that they take, the nature of the business and the impacts of their activities.

Finally, much of the data is taken in units of pieces and weight which makes summary assessment difficult both domestically and globally. It is proposed to follow the system of unit conversion of Green and Shirley (1999) where the value of a piece of live coral is valued at 200g /piece and that of the curio coral 500g/piece. In the latter, the material should be weighed directly to avoid the conversion and provide absolute weights.

6.2 Live coral: hard and soft

There is limited data available concerning the longer term exportation of live coral, both hard and soft. This is due to reasons listed in the previous section. The error factor in the existing Fisheries Division data, may be inferred from the precise data the largest exporter of live material. Over the a seven month period in 1999, permits were issued for 189,270 pieces of live hard coral. The amount of material actually sent was 16,996 pieces which comprised material collected from other Pacific Islands and Bali, Indonesia. The amount of trans-shipped material is unknown but a component from Tonga is on the order of 20-25% of the exported figure. Collectively, the amount of material collected in Fiji and elsewhere amounts to 9% of the total recorded from the hypothetical maximum export permit numbers.

The non-scleractinian varieties of soft corals, anemones and zooanthids are not as inflated with the collective numbers sent in the seven month period 22,996 pieces. Though the permitted and recorded quantity was 50,450 pieces, a figure 46% higher than actually exported. Once again these represent a composite export from varied locations.

6.3 Giant Clams: *Tridacna spp.*

One of the aquarium products which has become popular are juvenile giant clams. These are clams of the genus *Tridacna* and generally measure from 4 -12cm in length. They are popular because of their bright, multi-coloured mantle and the lore which reputes the large clams to be able to capture and drown an unsuspecting diver. Most of these animals are captive bred and imported for re-export. An exemption permit is required for the export of wild stock as it is banned for collection by the Fisheries Act. Both Ocean 2000 and Walt Smith Int'l export giant clams. Wild stock is preferred because of the brighter and more varied colour (Fig. 1g). In Fiji, the Fisheries Division operates a clam hatchery on Makogai Island, Lomaiviti with the potential for commercially taking advantage of this market.

As with the export of the live organisms, the export of clams represents product from various origins and a permitting system which has led to distortions in the amount of clams collected in Fiji. In the first seven months sampled in 1999, the largest exporter shipped 11% or 5,768 clams from all sources through permits which allowed for 53,430 clams and was recorded as the quantity exported. Most of the clams originate from outside Fiji.

6.4 Live Base Rock or Coral Base Rock

Live Rock is exported as small, irregular boulder shaped reef rock measuring on the order of 15 – 35cm at the maximum dimension. Unfortunately, the same record keeping problems occur with the live rock as with the other live exports, trans-shipment and large permit quantities provide little understanding of the amount of material actually being exported from Fiji. In the first seven months of 1999, the largest exporter shipped 291,837kgs of live rock within a permitting quota of 606,000kgs. As with the other statistics, this is the figure which was recorded as a Fiji export despite it being 52% high and comprising trans-shipment from Tonga.

Of interest is the increasing saturation of the market with the wholesale price of the live rock in the United States dropping from $2.75/lb to $1.10/lb over the three year history of the export. The poorer quality of some of the product has been implicated in the decline in popularity.

6.5 Unworked or curio coral

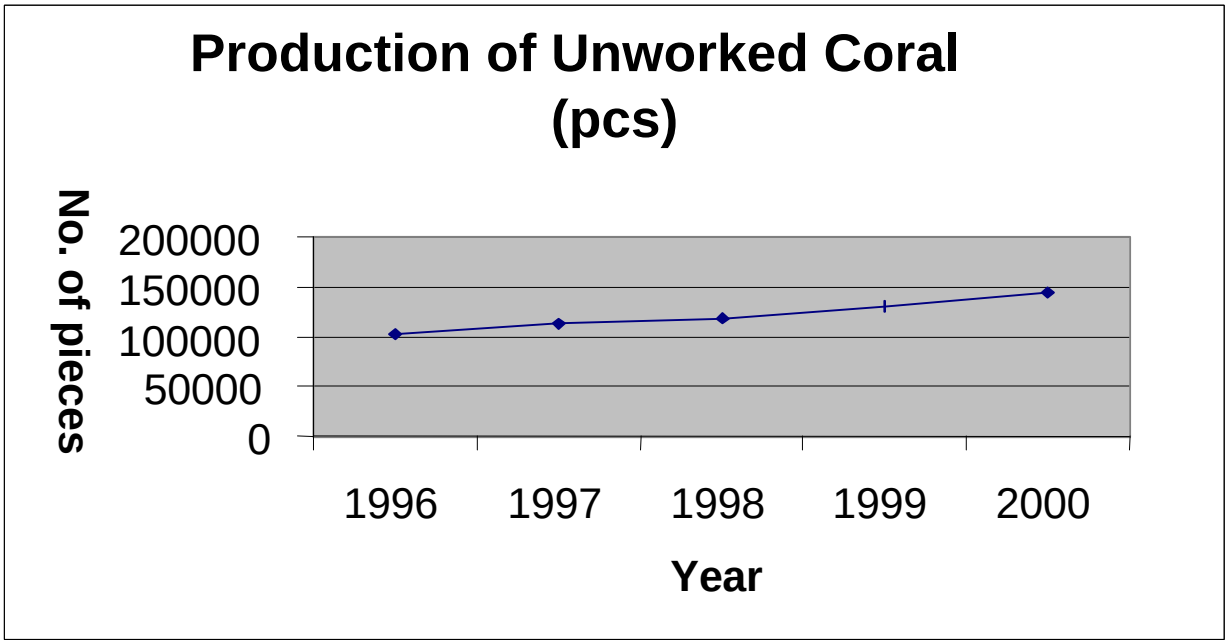
Unworked coral is curio grade coral. Export figures between the years of 1985 and 1987 are for Seaking Trading Co. Following is a table showing the species and the number of pieces.

Table 3: Species of Hard Coral Collected for the Curio Trade (After Viala, 1988; Lewis 1992)

Species	Trade name	1985	1986	1987	1988	Number of pieces
Acropora arcuata?	small branch	2921	6038	7640	455	17,054
A. echinata	pine tree	0	608	1128	783	2,519
A. humilis	Finger	5425	682	2008	219	8,334
A. nobilis	Staghorn	2189	1909	3882	482	8,462
A. palifera	Catspaw	457	1715	2236	632	5,040
A. prostrata?	Table	9546	6030	1606	0	17,182
A. subglabra	Tree	7449	2561	876	0	10,886
A. vaughani	Table	2	11	2404	294	2,711
Agaricia tenuflora?	mushroom (?)	0	0	342	0	342
Dendrophyllia micranthus	octopus	0	0	244	0	244
Echinopora lamellosa	lettuce/rose	285	173	32	28	518
Euphyllia divisa	divided brain	15	32	40		87
Fungia concinna	mushroom	1344	1320	742	235	3,641
Galaxea fascicularis	tooth	0	0	350	0	350
Goniastrea spp.	brain	762	856	1838	0	3,456
Herpetolitha spp.	slipper	216	374	1288	459	2,337
Leptoria phrygia	closed brain	0	30	5510	194	5,734
Leptoseris fragilis	glass	0	0	20	9	29
Lobophyllia corymbosa	open brain	0	0	1408	0	1,408
Mendusa? *Korei*	korei	0	0	380	3	383
M. lakeri	lakeri	0	0	126	132	258
Merulina ampliata	merulina	44	8648	4448	536	13,676
Merulina spp.	star	0	86	116	1	203
Millepora dichotoma	fire	0	0	594	93	687
Millepora spp.	fire	930	1118	3100	0	5,148
Montipora striata	montipora	0	0	94	0	512
Montipora spp.	Bermuda	0	0	512	0	94
Pachyseris rugosa	rugosa	0	0	304	98	402
Pavona frondifera?	lettuce	0	0	1262	13	1,275
P. lata?	cactus	0	0	840	110	950
Pectinia lactuca	lettuce	0	0	504	0	504
Pectinia spp.	cluster	5385	2359	3480	19	11,243
Pocillopora damicornis		0	0	134	0	134
P. eydouxi	cauliflower	134	705	1192	375	1,443
P. verrucosa		0	0	48	0	48
Porites spp.	porites	0	213	1230	0	134
Sandalolitha spp.	cup	0	3	682	0	685
Seriatopora hystrix	birds nest	1896	2281	5620	189	9,986
Stylaster spp.		0	0	68	0	68
Stylophora pistillata	elkhorn	2464	2461	2194	237	7,356
Stylophora spp.	black elkhorn	0	0	362	54	416
Tubipora musica	pipe organ	1772	641	1002	676	4,091
Turbinaria mollis?	rose/cup	0	52	140	22	214
Turbinaria spp.	frond	48	0	384	69	501
Zoopilus echinatus	big cup	0	0	16	0	16
	fan coral	0	0	36	19	55
Total		43880	41273	73238	6436	136,111

Production figures represent the collection of whole hard coral colonies by Acropora Int'l. Annual export for 1996 was 102,749 pieces and for 1997 was 113,024 pieces which represents a 10% increase. This year exceeds the quantity (111,697 pieces) shipped from Fiji each year during the four year period 1985-1988. The market is clearly larger. These figures represent material collected in Fiji only.

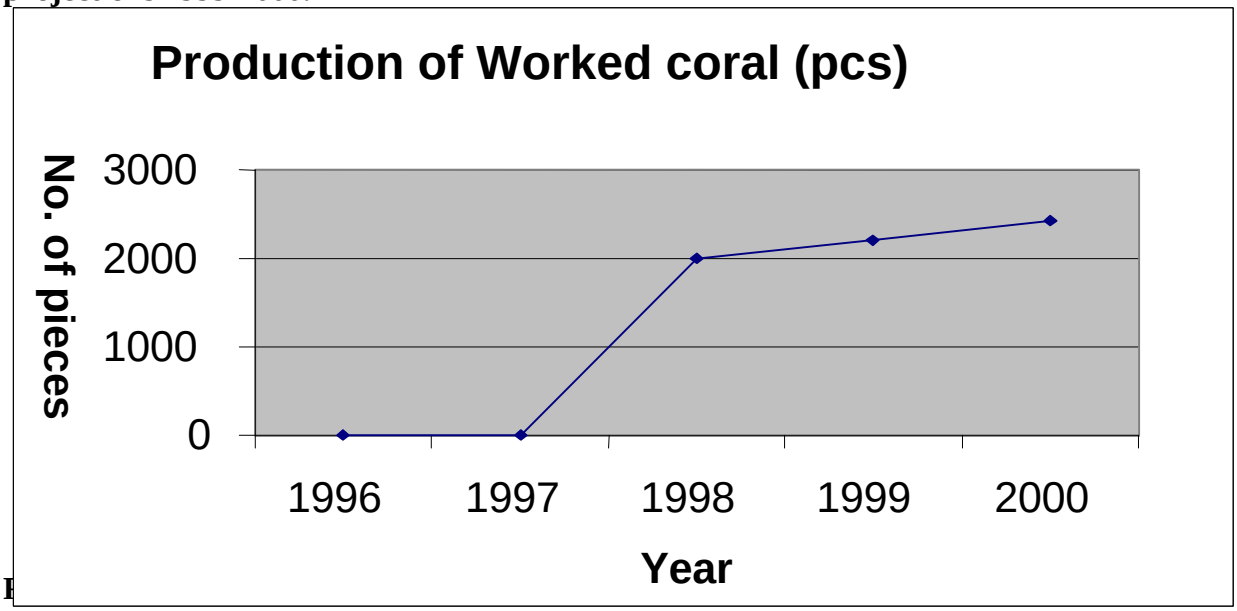
Figure 8: Export of unworked or Curio coral for the years 1996-1998 with projections 1999-2000.



6.6 Worked or Value-added Curio Coral

This is curio coral which is in some way processed. It is cleaned, bleached and sometimes dyed. It may be formed into decorative objects through lathe work or complimentary pieces as decorative items. Packaging involves individual shrink-wrap packaging and employing a bar-coding pricing system.. At this stage the export level is low. Seaking Trading Co. is holding a large quantity of unworked material. Initial problems with the processing end of the operation have limited product flow. The figures 16, 17, 18 represent Fiji collected material and don't contain trans-shipped material.

Figure 9: Export of worked or Value-added Curio coral for the years 1996-1998 with projections 1999-2000.



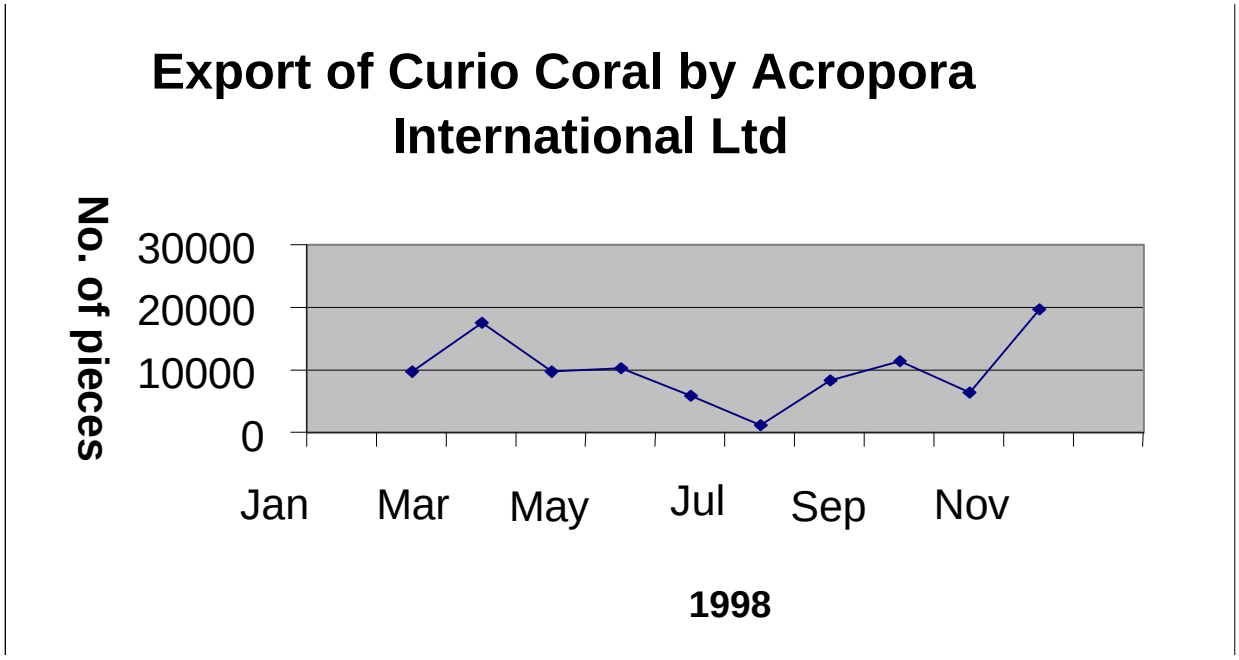
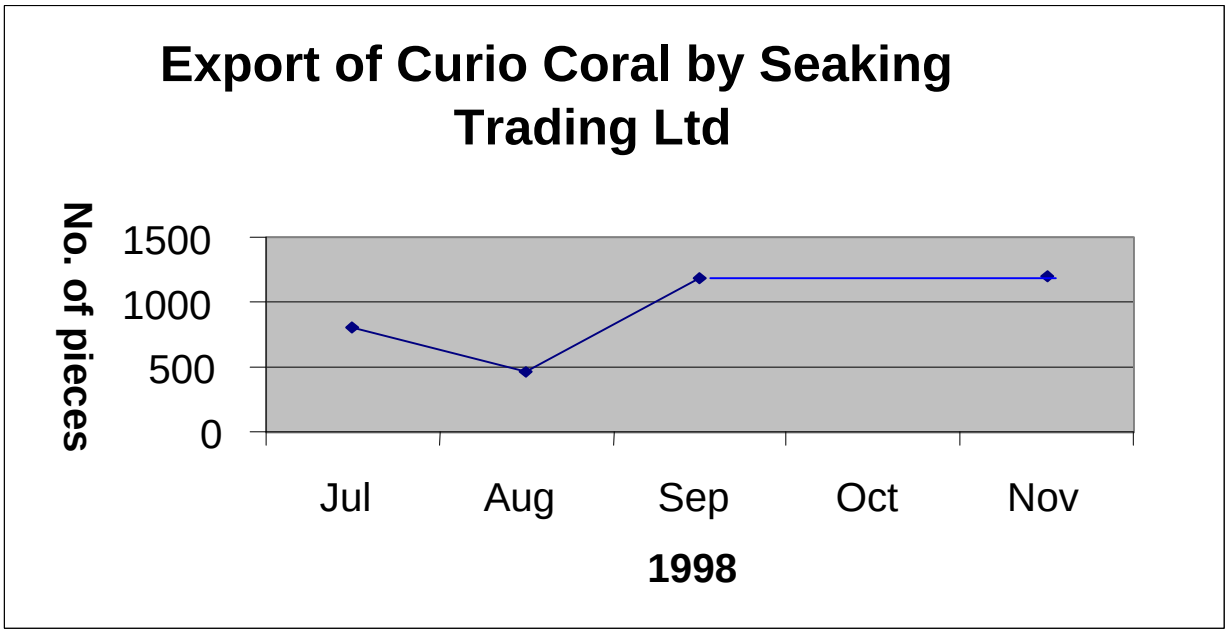


Figure 11: Export of Value-added Curio Coral by Seaking Trading Co. for five months in 1998 (Fisheries Division Data).



7.0 RESOURCE CUSTODIANS AND COMPANIES

To determine if there was an apparent change in the qoliqoli fisheries as the result of the removal of the reef products, information was obtained through a questionnaire Consultation was conducted with the custodians. Three of the villages are involved in the *live rock* harvest and two are involved in the curio trade. Discussions were held during the sevusevu and interviews with those employed in the live rock and coral collection. Some of the interview focused on the questionnaire where the objective was to ascertain the effect of the live rock extraction on the local fishery. The results were inconclusive with conflicting accounts. The absence of data confounds objective interpretation. It was apparent that the replies to the questions were influenced by whether the respondents were employed in the extraction. To determine the affect of the mining on the fishery will require a sampling program that will provide data on the diversity and abundance of fish in the area of extraction in comparison with similar unaffected areas.

7.1 Fisheries questionnaire and interview

Fifteen interviews were conducted. The objective of the questionnaire was to determine whether there had been a decline in the local fisheries as the result of the live rock or curio coral extraction. The questionnaire is included in the Appendix 14.4. Answers to the question are contained in Appendix 14.4b as well as the sample characteristics. Following are the responses to the questions pertaining to the longer term decline of the fishery and that which occurred during the period of the coral products removal. The interviews were held Oct. 15, 1998 for Malomalo Village, Oct. 16 for Naidiri Village and October 23 for Vatukarasa Village.

Has the amount of catch changed over the period of your life?

Malomalo		Naidiri		Vatukarasa	
No	Yes	No	Yes	No	Yes
20%	80%	57%	43%	50%	50%

In Malomalo, there was no concurrence as to the nature of the change. Some say that in earlier years, larger fish were caught and abundance was greater. The catch is now diminishing. Others say there is an increase in the daily catch and abundance. The no category believes that their have been no changes and the catch has been consistent. The main determinant of the catch is the weather and natural seasonal variations.

At Naidiri, change was detected by fewer respondents. It was attributed to an increase in fishing activities over time which now requires a greater effort to obtain the required catch. More than half thought that there was no change and that the catch seems to be much the same.

At Vatukarasa, half of the respondents thought that that it had changed with the catch decreasing and half thought that it hadn't. Any change in the amount of catch was attributed to natural cycles such as tides, seasons and weather.

Has the amount of catch changed in the area where the *live rock* is being extracted?

Malomalo		Naidiri		Vatukarasa	
No	Yes	No	Yes	No	Yes

47%	53%	100%		37%	63%

At Malomalo, opinion is divided as to the nature of the change that has occurred as the result of the live rock extraction. 71% thought that there was an increased abundance of various reef fishes due to the removal of dead coral and the increased regrowth of macro-algae which attracts the fish . The increase is mostly algal feeding fin-fish. An increase in the abundance of octopus was indicated.

29% thought that there was a decrease in fin-fish caught with one comment indicating a dramatic decrease. The amount of octopus had decreased. 37% thought that the abundance was constant.

In Naidiri, none of the respondents indicated that a change in the amount of fish caught was evident in the area where the coral was being taken. The types and abundance of fish remained the same in the area adjacent Naidiri. The coral extraction has provided much more money than that previously received by selling the fish.

At Vatukarasa, seventy five percent indicated that there had been a change in the area of the coral extraction. In one instance, this resulted in an increase in fish, presumably due to the increase in algae as the result of the disturbance. In 62% of accounts there was an observed decrease in abundance . This perception was due more to the population pressure, loss of habitat and the use of the poison duva (Derris). Observations referred to the reef flat with not much change evident on the reef edges and slopes.

Only 25% thought that there had been no change at all during the period of the live rock extraction.

With respect to the curio harvest, Seaking Trading Co. and the custodians for the area of collection adjacent to Viti Levu Bay were interviewed on November 12, 1998. This involved a *Sevusevu* with the Tui Navitilevu, Ratu Isikeli Vakabaletabua an interview with the Tauraga-ni-koro, Joseva Qiokata, and other villagers at Navuniivi, the paramount village in the qoliqoli. The qoliqoli vanua's are Navitilevu and Nagilogilo, encompassing the southeastern shore of Viti Levu Bay and extends offshore toward Vatu-I-Ra Passage where there are a series of patch reefs 4 -7 miles offshore from Navuniivi.

The collection of coral in this area is recent with the collection of a large quantity being taken during the period of March to May, 1999. The collection was then stopped by the Fisheries Division who considered the amount of coral being stockpiled excessive. The collectors were delighted at the opportunity to collect the coral and utilised nine boats from three villages to amass $379m^3$ of coral now stockpiled on shore. It was evident from the export record of Seaking Trading Company that this material was far in excess of their capability to export in a timely manner. Disappointment was shared by the village collectors who would have preferred to continue collecting. The stockpile of such a large quantity of coral was also an embarrassment to the Tui Navitilevu who expressed dismay at such apparent waste, given that the business arrangement was for a much smaller extraction of material.

Several management problems exist with this business. No prior assessment was made of the resource and no environmental impact assessment exists. There was no strategy of collection but rather the field operation rested on the objective of filling the boats. Collection of the material was not based on overseas orders, except in a general or categorical sense. Much of the material is in

unsuitable for sale due to its large size or damaged condition. The collected material was stored on a black sand beach where the material is subject to contamination and weather which renders some of the product unsaleable.

8.0 MANAGEMENT RESPONSIBILITIES

Discussion of the nature of coral products removal is at times polarized due to the uncertain nature of the fishery. The product collected has only been done so, in most cases, for less than a decade and the consequences are unclear. Considerations of management and likely impact are timely. This prompts the question, who is ultimately responsible for the management of this fishery? Is it the choice of the qoliqoli custodians to utilize their traditional right to harvest from the area as they see fit? What role does the Fisheries Division play? What is their legal authority? How are these integrated into the decisions made by the custodians?

The answers or lack of, lie with an understanding of the system of coastal governance known as the *Dual Tenure System.* Here the responsibilities for management of the aquarium products and curio industry reside both with in the rights of customary marine tenure of the *qoliqoli* and with the Fisheries Divisions under authority of the Fisheries Act. This sharing of the responsibility of the management of the customary fishing rights areas has been a workable arrangement since the time of Cessation, though no real interest in management until the 1950's. Additionally, opportunities for the Custodians to further capitalize on their marine resources has led to the involvement of commercial operators in the management of removal of coral related products.

8.1 The Dual Tenure System of Management

Governance of the coastal marine areas by Government and the traditional custodians is referred to as the Dual Tenure System. It represents the acknowledgement that villages have exclusive fishing rights to specified inshore areas that have traditionally belonged to them and is referred to as Customary Marine Tenure (CMT).

The extent of indigenous Fijians sovereignty over the sea, however, has been a controversial subject since the instilling of Colonial rule. Conflict in fisheries management stems from the lack of a clear interpretation of the rights conveyed to the coastal Fijians at the time of Cession (1874). With colonization came the governance of the laws of England. The first governor, Sir Arthur Gordon, developed the political and legal framework for modern Fiji. Replying to the concern of the chiefs about the use of the reefs as a resource necessary for survival of the coastal villages, he conveyed the message from the Queen that the fishing rights were the sovereign rights of the Fijians. The general interpretation of the wording of the proclamation was that the rights conveyed related to fishing rights only. Prior to that, the reef areas were treated like land title and the rights, which represented complete ownership, were acquired through marriage, politics and war. Customary Marine Tenure (CMT), the relationship between the community and the fishery area, encompasses the proprietary right to traditional fishing in nearshore waters and coral reefs from mean high water mark to the outer edge of the associated fringe or barrier reef.

From UNEP/ IUCN (1988)), the boundaries to these areas are recorded by the Native Lands and Fisheries Commission (NLFC) and are often seaward extensions of boundaries on land, although rights over the marine area are rights of use rather than ownership. Fishing rights boundaries have been recorded for all the islands. Under British tidal law, however, all land below MHWN and extending outwards to the ocean edge of the outer reef is legally defined as the property of the Crown. In fulfillment of the pledge in the new colony by Sir Arthur Gordon, all reefs and shell fish beds have been assigned by the Native Lands and Fisheries Commission to members of the indigenous Fijian race for purposes of subsistence fishing and harvesting. They may be licensed to fish commercially and have the right to permit or refuse application for commercial fishing. For a

development which can be shown to have adverse effects on fisheries, fishing rights compensation has to be paid to the native fishing rights owners after an environmental impact and fisheries assessment has been carried out (Lal, 1984)

Traditional customs and practices have evolved to regulate the use of inshore resources. Elements of management that are part of the rights exercised under the Customary Marine Tenure system are the placement of tabu's on *qoliqoli* areas. This may result from the death of a chief or someone of high rank as a mark of respect or tribute. Tabu's are also placed on forbidden fishing practices.

Zann and Vuki (1994) describe the legality of CMT.

> Legal Framework
>
> The extent of indigenous Fijians sovereignty over the sea has been a controversial subject since Cession. Under Clause 4 of the 'Deed of Cession" the islands, the waters, reefs and foreshores not properly alienated and not needed by Fijians are vested in Her Majesty and Her Successors. There were some uncertainty after Cession as to the ownership of reefs and fishing grounds as they were traditionally the property of Fijian communities, and like land were required for their use and sustenance (Pulea, 1991).
>
> The Rivers and Streams Ordinance No. XIV of 1880 abolished traditional fishing rights in rivers and streams, which were to be perpetually open to the public for the enjoyment of all. However, the Fisheries Ordinance No. III of 1894 recognized the mataqali's rights of exclusive fishery on certain reefs and made it unlawful for any other person to do so without obtaining a license. This was subsequently included in the Birds, Games & Fish Protection Ordinance No. 20 of 1923. Ordinance No.4 of 1941 made provisions for the "regulation of fishing". It established the Native Fisheries Commission with the duty to ascertain what customary fishing rights are the rightful and hereditary property of native owners, and to establish the title of all customary fishing rights. This was incorporated into the Fisheries Act of 1942.
>
> Reef Tenure and Property rights
>
> The State claims legal ownership of all land below mean high water mark (MHWN) and extending outwards to the outer reef edge. Although the legal ownership resides with the State, the traditional fishing rights of indigenous Fijians as customary owners have been safeguarded and recognized either by legislation or in a de facto sense. The recompensation system, established in relation to mangrove and foreshore reclamation, requires a developer to recompensate the traditional fishing right owners for the loss of fishing rights and resources as a result of loss of nursery and breeding grounds (Lal, 1983). This recompensation sum is held in a trust fund and only the interests are paid to present and future generations of customary right owners.

8.2 Coastal Zone Management

The littoral zone, foreshore and submerged sea floor are held by the State (State Lands Act 1946). In the case of the development of these areas, laws require the approval of the Minister for Lands and the details of the leases must be gazetted prior to approval for public comment. Compensation for rights infringements and disputes fall under the State Acquisition of Lands Act. Fishing rights are compensatable through the Native Fisheries Commission. The lessee is responsible for access and environmental matters. Natural ecosystems such as mangroves and coral reefs are protected through environmental impact assessments that have become part of the conditions of the lease.

Chapter 1, Section 9(7) of the 1997 Constitution state that royalties for mineral, that include gas and oil, extracted from within customary fishing rights areas are paid to the rights holders.

The variety of legislation and agencies that are entrusted to manage it, create coastal zone management (CZM) problems in terms of jurisdiction. The dual tenure system of governance of shallow subtidal areas increases the political complexity. The rights and reliance on the traditional subsistence and artisanal fishery by the custodians of the is at times in conflict with developments for industry and tourism.

There is at present an inadequate legislative infrastructure for the conservation of critical marine habitats and environmental controls are dispersed amongst several different acts and regulations. Some of the legislation and management relating to the coastal zone are briefly described in SPREP (1980) and Zann (1992). The proposed Sustainable Bill is an attempt to unify and strengthen environmental legislation.

Many of the CZM problems are the result of the absence of a comprehensive integrated coastal zone management plan. This lack has led to an arbitrary approach to activities in some coastal zone areas. Conflict of interest, lack of policy and clear authority has had a negative impact or given rise to inappropriate development or practices. Developments have taken place without environmental impact assessments and without any punitive legal action by the authorities responsible for their regulation. The unclear status of rights under Customary Marine Tenure has occasionally given rise to conflict between fishing rights stakeholders and commercial operators. Use of the coastal waters is an example. In the case of aquarium coral product extraction, it is the custodians who enter into a contract with the entrepreneurs effectively managing the collection or extraction of the product. Business enterprises have taken a leading role in the development of the industry. Management has been effective with the commercial operators progressively developing contractual or working relationships with the qoliqoli custodians for the collection of product.

8.3 Fisheries Division

Responsibility for fisheries matters lies with the Ministry (Minister) of Agriculture, Fisheries and Forests. Within this Ministry, the Director of Fisheries oversees the work of the Fisheries Division of the Department of Agriculture and Fisheries, which has its headquarters at Lami, on the western outskirts of Suva.

The laws relating to marine resources in Fiji are enshrined in Chapters 158, 158A and 149 of the Laws of Fiji. Chapter 158, the Fisheries Act, recognizes the Fijian people's customary right to fish in traditional fishing grounds (**qoliqoli**), and allows the owners of customary fishing rights to advise the District Commissioner and Fisheries Division which commercial fishermen shall be allowed to fish in their area and to impose restrictions on commercial fishermen. The Fisheries Division is responsible for providing advice on their fisheries to customary fishing rights owners and issuing fishing licenses to commercial fishermen. It is also responsible for enforcing fisheries laws inside and outside the reef. Licenses to fish in customary fishing rights areas are only issued to fishermen who have already obtained a permit from the head of the relevant ownership unit.

The Minister for Agriculture, Fisheries and Forests may make regulations under the Fisheries Act relating to the management of fisheries resources, which after Cabinet discussion and approval, are promulgated by publication in the Fiji Gazette. Fisheries Division relies on traditional administrations to take responsibility for the regulation of inshore fisheries, while it concentrates on the deep-sea fisheries, mainly those for tuna and deep water bottom-fish. Fisheries Division also has a network of Honorary Fish Wardens, appointed by the Minister on the request of the head of the unit which owns the customary fishing rights, their duties being centered on the prevention and detection of offences under the Fisheries Act and the enforcement of the provisions of the Act. (Andrews et al. 1994).

Management of the aquarium products and coral harvesting industry, at present, lack clear and consistent management by Government. Guidelines exist but do not cater for the varied aspects of the industry. The reactionary approach to problems has led to inconsistencies in the application of guidelines. Kialola (1995) pointed out that the management was "generally passive sometimes rising to reactive".

8.3.1 Fisheries Regulation

The Fisheries Act doesn't specify the aquarium products or those of the curio trade and at present considers coral as an "..aquatic animal whether piscine or not..", and comes under the definition of "fish" in the Fisheries Act, it is subject to the various restrictions on exploitation of fish listed in the Act. For example, the export of live coral is banned, in the same way that the export of live fish is banned, subject to explicit ministerial exemption (Richards et al.1994).

The role of Fisheries Division is often supportive in providing export permits and satisfying CITES documentation, though re-export of coral reef products from the areas outside Fiji may breach the CITES agreement. Control of the fishery is based on adherence to guidelines and policy for the issue of export permits. The Fisheries Division has no legal basis for requiring the issue of such permits. The permits are issued as an *ad hoc* arrangement with the Customs Department (see section 9.3).

8.3.2 Policies on licensing

For entry into the industry, there are two approaches depending on whether you are a national or an expatriate investor. In all cases, permission must be granted by the *native customary fishing right area* custodians, prior to the harvesting. This must be endorsed by the provincial administration and given to the Fisheries Division. In the case of the expatriate seeking to enter the industry, the Fiji Trade and Investment Board (FTIB), a statutory body, requires the custodian and Fisheries permissions as well as satisfying their own criteria for foreign owned businesses in Fiji. FTIB administers a series of incentives for potential investors. These include tax exemptions, duty-free import of equipment and accelerated depreciation provisions. It is general practice for investors to work initially with FTIB, which then advises the Business and Industrial Development Committee (BIDC), the Ministerial-level final authority, on whether or not a proposed venture should be approved. The FTIB liaises with relevant Government departments in making its final appraisal of proposals. Its operations are in line with the government's policy to shift production from import substitution to export-oriented industries.

For the removal of aquarium products and curio coral, licensing arrangements are inconsistent. In some cases the entrepreneur is licensed and in others the custodians. Only one collector is licensed but represents associates who collect as a team. A general fishing license can not be used to collect coral if it was issued for fin-fish. The exporter must comply with the fisheries directives and guidelines or an export permit will not be issued. (see Section 9.3)

8.3.3 Coral Harvesting Guidelines (Policy) Set by the Fisheries Division

Following are the guidelines presently used by the Fisheries Division. They have been developed substantially from the original set which were initiated in 1984 to regulate the curio coral trade but now cater for the present types of extraction.

1. Prior to the harvesting of any coral in any Native Customary Fishing Right Area for the purpose of business, the following should be observed:

a) an approval in writing be given by its legal authority (qoliqoli) and endorsed by the provincial administration;

b) this approval is to be forwarded to the Fisheries Division.

1. An EIA is to be carried out prior to any harvesting/extraction within the requested area. It will be the responsibility of the company to produce an EIA to the satisfaction of the Fisheries Division and the Ministry of Environment.

2. A map with a demarcated area will be allocated to the licensed divers to harvest corals. The licensee should only collect corals in the demarcated reefs.

3. Collection activities should not concentrate for too long in any one site or area.

4. Collection should concentrate in areas of good growth, preferably on barrier reefs not shoreline reefs that are characterised by low pool due to inshore effects.

5. Actual (continuity of) coral harvesting for trade or business will be dependent on the favorable outcome of the survey report. Periodic monitoring will determine that the harvest is sustainable.

6. Fisheries Division should be notified of new collecting areas prior to harvesting so that survey can be carried out to assess the total allowable harvest that can be sustained from the area. The expense of this survey is to be borne by the operator. No collection is to occur prior to the Fisheries Division survey and approval.

7. Such license may exclude harvesting in certain area claimed and registered by the Native Fisheries Commission to be known as *kanakana* (subsistence) of the Mataqali.

8. Local resource custodians are to do the collecting. The company's part in collection activities is marketing, training and advisory.

9. The Fisheries Division will consult with collectors and resource custodians on management measures and give notice of over exploitation, if it occurs. (Fisheries warden or contact person in the qoliqoli to facilitate communication)

10. The buying company is to make sure that collectors know which varieties and grades are acceptable to the company. This will minimise over-exploitation and wastage.

11. Each consignment for export will require an Export Permit from the Fisheries Division. The nominated Fisheries Officer will only issue this permit on the presentation of the list of all corals to be exported and after the inspection of the consignment.

12. The Fisheries Division will not become involved in any financial dispute between the collector and buyer.

14. The failure to abide to the above guidelines will automatically result in the cancellation of the fishing license.

8.3.4 Fisheries management difficulties

Problems encountered by the Fisheries Division are several fold. Their financial resources and manpower are not adequate for them to attend to all of the requirements of the varied fisheries inshore

as well as those offshore. A firm policy is now being developed with regulations of the industry with consequences of the policy is not adhered to. The ability to monitor the varied operations needs to be enhanced. Itemized are the principal problem areas:

1) Management needs to be informed and timely, in both decision making and communication with the industry.

2) Resources at the Fisheries Division do not allow for adequate monitoring. Monitoring capability needs to be upgraded.

3) Record keeping needs to be improved to conform to CITES requirements and provide adequate information on Fiji's coral fisheries. Summary information, which includes items designated as trans-shipment, must be recorded only and not hypothetical permitted exports.

4) There is inadequate legislation for regulation.

5) The custodians feel they have the right to manage their qoliqoli as they see fit.

6)The custodians may lease access to their fishing grounds to several operators creating conflict and increasing the pressure on the resource.

9.0 ENVIRONMENTAL IMPACT ASSESSMENT

In the absence of research on the effect of the extraction of coral or live rock from a reef system, general opinion relies largely on presumption drawn from general ecological theory. Without quantitative information, discussion of the subject is unable to result in conclusions based on the particular situation in question. Without a complete understanding of the ecological relationships (composition of the reef community; the recruitment rates) discussion will waiver with the danger of self interest differentially weighting the argument to confirm a subjective appreciation. Unfortunately, the reality of the science surrounding this subject is that there is inadequate understanding of the natural system and the effect on it by coral extraction. It is largely a discussion of circumstances and assumptions with conclusions arrived at without data. As required by the Fisheries Guidelines, a survey of the resource followed by a monitoring program is the first step to a better understanding.

9.1 Ecological and Biological

The ecological considerations vary with the type of activity. Important considerations in assessing the likelihood of impact are the sizes of the qoliqoli or collection areas. Equally important is the abundance of material with in these areas. This assessment relies on an understanding of the amount of habitat which is suitable for product collection with in the qoliqoli. The larger the area, the greater the opportunity for recruitment at sustainable levels.

9.1.1 Live Coral (Fig 1a-h)

The collection of live coral represents a promising fishery. There is an abundance of reef organisms which have formerly had no commercial value. Market requirements limit both the size categories as well as the numbers of individuals taken. Due to the variety of the species and the lack of information on their life histories, the impacts, in a particular sense, are unclear. The fact that qoliqoli areas are large and that only some of the colonies, due to size or condition, are suitable for collection make over-collection unlikely. The large peripheral areas that are, at the present time, uncollected suggest continuous recruitment. The prohibition of underwater breathing

apparatus means that the deeper material remains uncollected. Monitoring of this new fishery is important to its development.

Points summarizing the positive and negative aspects of an environmental impact assessment on the fishery are:

Positive considerations that promote sustainability are:

1) the product has a defined size limitation
2) large areas available for collection
3) diversity of reefs or habitat provide a situation whereby areas of accessible collection are seeded by other reefs.
4) remoteness of the collection areas

Problem areas associated with this type of collection are the difficulties in:

1) assessing a resource of unknown abundance
2) assessing the role of organisms whose life history are incompletely known
3) developing the monitoring methodology to provide an ongoing understanding of the impact of the fishery on the reef system or qoliqoli.
4) cost in assessing remote locations or of a substantial area.
5) Conflict exists both with tourist operators and village perceptions on the long term effect of coral harvesting activities in their area.

The two operators Walt Smith International and Ocean 2000 Ltd. both have large, remote areas available for collection. The qoliqoli boundaries are shown in figures 12 and 15 respectively. The reef area and types are shown in the areal photographs of the collecting areas.

Figure 12: Qoliqoli boundaries representing the collecting areas of Walt Smith Intl.

Figure 13: Aerial photographs of reef types and areas within the qoliqoli (Fig. 12).

Figure 14

Figure 15: Qoliqoli boundaries representing the collecting areas of Ocean 2000 Ltd.

Ownership

1) Vanua – Verata
2) Vanua – Kabuna
3) Yavusa – Nayaumunu
4) Yavusa – Nautu and Nacovu
5) Yavusa – Naikawaga and Vugalei
6) Yavusa - Batiki
7) Yavusa - Levukana
8) Yavusa – Toga
9) Yavusa - Nalewadina, Naveisere and Nawainovo
10) Yavusa - Koronikalou
11) Yavusa – Davetalev
12) Yavusa - Nakorolevu

Figure 16: Aerial photographs of reef types and areas within the qoliqoli (Fig. 15).

Based on the considerations in providing an environmental impact assessment, the collection of live aquarium products should proceed subject to the successful development of monitoring methods. These methods must be complimented by an evolving policy concerned with efficiency and effectiveness in promoting rational resource use. Field assessment, village consultation and awareness are important aspects.

9.1.2 Giant Clams (*Tridacna spp.)*

The export of the ***Tridacna*** clams grown in captivity represents a commercial success for mariculture. With the natural stock depleted through fishing pressure, hatchery grown material provides a solution to supply.

Wild caught specimens for export contravene the Fisheries Act which seeks to protect domestic food items. The small number of clams collected are done so with Fisheries approval but the guidelines for this approval are arbitrary. The clams are commonly sold as food items in the domestic market.

9.1.3 *Live Rock* (Figs. 2-4a-h)

Live rock removal is the mining of reef rock which was deposited during a former period and is not going to re-establish itself within tens of years, and probably longer in lagoonal areas. On the algal crest, replacement may be more rapid as there is a substantial algal component in the rock. Some reef flats are more amenable to *live rock* removal which results in an increase in ponded water in areas which have little relief and dry intertidally.

The sites where extraction was occurring were sampled using the line transect method for comparison between sites and with those not being harvested. What became evident was that the reefs varied substantially in their basic composition. By virtue of their extensive intertidal exposure, some areas were characterised by sand and rubble. Areas in the proximity of creek outfalls exhibited a preponderance of algae. It was characterised by a reef flat that had been filled in by the skeletal fragments of the corals killed by the periodic flooding. The deeper lagoon areas host good hard coral abundance. Given this range of fringing reef types, it is evident that there are some areas that would benefit from the extraction of live rock through the creation of a varied topography with the subsequent ponding of intertidal water. Equally, it is evident that other areas could be easily destroyed by the harvest of *live rock* such as in the deeper reef flat lagoons. Appendix 14.5 details the sampling method and compares the site data.

Aspects which are conducive to the *live rock* extraction:

1) Abundant supply as is often characteristic of a high energy zone
2) Areas of collection represent:
    a) Small portions of an qoliqoli are used so the potential adverse affects are limited.
    b) Best practice methods are peripheral to reef areas occuring in such areas as the algal ridge zone.
    c) Areas of low productivity for subsistence fisheries.
3) Enhancement of reef topography by increasing relief.

Potential negative impacts:

1) Potential for destruction of coral populations in the reef flat lagoon.
2) Potential for reduction of reef topography (micro-habitats).
3) Conflict with tourist operators who view the collection as reef destruction, compromising a valuable asset .
4) Presents a poor conservation image.

Considering the above points, it is clear that if a code of practice is adhered to that the environmental impact is minimal or acceptable on the balance of the favorable economic return. Easy access and limited areas of collection make monitoring of the resource relatively easy.

The decision has been made by some of the custodians that the benefits of employment out weighs the potential negative consequences. The extraction is carried out in only a portion of the qoliqoli and has provided continuous work for several years with substantial material remaining.

Following are four examples:

9.1.3.1 Malomalo Village (Koroniuniu Reef) - A portion of the qoliqoli is totally devoted to the extraction of the live rock (Fig 2a-h) (Figs. 17, 18). The reef flat is being utilized from shore to reef crest. The objective is to provide a weekly quota of *live rock* and the reef flat is being mined to provide the supply. The view adopted is that the benefit from the extraction outweighs the potential for negative consequences. It is felt that there are sufficient areas for subsistence fishing requirements elsewhere. A fisheries questionnaire highlighted the conflict in perception about the effect on the subsistence fishery. To accurately assess the state of the reef flat fishery, reliable data needs to be gathered. This coupled with periodic monitoring, would allow for a more complete understanding of the consequences of such large scale removal from the patch reefs in the inner lagoon. Elsewhere studies have shown that both abundance and diversity of fish are reduced as the result of such disturbance.

Ocean 2000 Ltd. extracts *Live Rock* from the qoliqoli of Malomalo village. This operation has been in existence for 4 years. The Chief of the village is Ratu Sola Maiyale, the paramount chief of the Vanua Tabanivono-I-Ra. (Malomalo) which includes the Yavusas of Leweisavu, Leweinavivasa, Tabanivono, Leweinuku, Noi Lau, and Leweivucini. The area being used for *live rock* extraction represents 27% of the qoliqoli. The villagers of Malomalo have the opportunity to utilize the neighboring qoliqoli's of Vanua Nosan and Vanua Ansonia for their subsistence needs.

Those employed in the business are as follows: Ratu Sola is the license holder for the live rock removal. The *Turaga ni Koro* manages the field operation. Ten families are involved in the mining of the rock. Five families alternate working as a team on a weekly basis as does the bullock driver. Some of the family members mine the rock and have been trained as to which material should be selected. Others load the rock on to the bilibili and transport it ashore where other members provide an initial cleaning, others provide support ashore by providing tea breaks and lunch. The truck and driver, who transport the material to Nadi, are provided by Ocean 2000 Ltd.

It was the general opinion of those engaged in the collection that the industry was of undeniable benefit. This was particularly so during the period of drought when there was no sugar cane to cut and that this an "opportunity sent from the Lord". There were no misgivings about the disruption of the reef and many said that the fishing was as good as it had ever been. The operation has continued for four years. The general routine was for twice weekly collection and shipments to the Nadi holding facility.

One interview involved a married couple who were not employed in the extraction and who felt that the fishery for kuita (octopus) and kawakawa (rockcod) had been substantially degraded. Despite this perception, they would like to be involved in the operation. Due to their initial opposition, they were not selected by the Chief for participation.

The adjacent village of Naidiri does not engage in live rock collection. There are strong opinions that this activity is very harmful to the reef fishery. The removal of reef rock destroys the area

formerly providing a reliable source of fish. The material that is being removed is the result perhaps hundreds of years of accretion and that the change that is occurring in this reef is irreversible. The fish products, formerly available from the reef, have been reduced. The collection of live rock has provided short term benefit only, with much of the money spent on food that is less healthy (i.e. cornbeef or lambflaps). Concern has been expressed that the benefits offered by the reef will be denied to future generations, being lost to this destructive activity.

9.1.3.2) Komave Village (Vatumalawa Reef) - South Seas Export Ltd. has mined live rock for three years (Fig. 4a-c) (Figs. 19, 20) As with Malomalo, only a portion of the qoliqoli is being used for extraction of the live rock. The ecological impact on the area is similar to Malomalo with the reef flat being mined from inshore to the outer margin. There is proliferation of macro-algaes in the area where the rock is being taken. The diversity of coral in this area is low with only the massive *Porites* representing the living coral. At first inspection, it appears that the reef had been affected by the operation as the species diversity of coral is low and macro-algae abundant. Fortunately, there is a good comparison with an adjacent reef that has never had the *live rock* harvested. This is Nalumu (Navola) Reef and is located at the southern end of the Vatumalawa Reef. It experiences the same physical environmental regime as does the area of activity. Interesting, both portions of the reef flats are similar having low living coral and little relief on the outer portion of the flat. The lagoon inshore is narrow and shallow. This appears to be the result of the reef flat being largely conditioned by its proximity to several freshwater out flows. These are Komave Creek, Navola Creek and the Namatakula River. Field observations, after the first rainfall in six months, showed that coral growth which had occurred was killed by the freshwater run-off. The resulting skeletal material would then be deposited on the reef flat which was characterised by loosely packed coral skeletons of the same genus. This is largely branching material of the fast growing genus *Acropora.*

9.1.3.3) Vatukarasa Village - *Live rock* is taken from two sites one of which is a reef flat similar to the Vatumalawa reef in having a small, shallow inshore lagoon area with a general lack of relief over the reef flat (Figs. 21, 22). As with the Vatumalawa reef, there are two rivers, the Sovi and the Tamanua rivers which empty into bays on either side of the reef, create a cycle of periodic coral settlement, growth, and death due to flooding with subsequent deposition and consolidation by coralline algae. It is this material that is the source of *live rock* (Fig. 3a)

The other site (Fig. 3b-h) has an inner lagoon which is characterised by a good luxuriance of coral. It is surrounded by an algal crest or flat which extends along the western margin of Sovi Bay and along the seaward edge along the south of the reef flat. It is from this algal ridge that the reef rock is taken without disruption to the inshore lagoon environment.

9.1.3.4) Suva Harbour - In the case of the extraction of *live rock* from this area, the material comes from two sources. One area is characterised by rocks which lie unattached on the subtidal reef flats which have the desired coralline alga on their surfaces. The second source is from the dead base area of the live coral from the extensive areas of coral growth adjacent Muaivuso Village (Fig 4e-h).

The collection of *live rock* from the subtidal, inshore areas appears to have little impact on the living coral. This is because the abundance and diversity of coral is low and confined to species resistant to a physical environment where water clarity is reduced and sedimentation and river effluent are persistent. By contrast, the effect of taking the *live rock*, which comprise the bases of the large stands of living coral, will progressively have a disruptive effect on a uniquely luxuriant

Figure 17: Qoliqoli boundaries representing the *live rock* collecting areas of Ocean 2000 Ltd.

Ownership

2) Vanua Nasoqo
3) Vanua Tabanivono (Malomalo)
4) Vanua Yasuasuna

Figure 18: Aerial photographs of reef types and extent of the qoliqoli (Fig. 17).

Figure 19: Qoliqoli boundaries representing the *live rock* collecting areas of South Seas Export and Walt Smith Int

Figure 20: Aerial photographs of reef types and areas within the qoliqoli (Fig. 19).

area of the reef. The habitat relief in this area is substantial representing some of the best coral development in the area. The progressive removal of this stand of coral would represent, in relative terms, a substantial loss of limited habitat.

Contrary to Fisheries policy there are several operators working in the same area (Figs. 23, 24). This is the result of the Tui Suva and the Chief at Muaivuso allowing several operators all of who pay lease money (see Section 11.5).

9.1.4 Curio Coral

The main points that apply to the live coral collection apply to the curio coral. An important distinction is that the curio coral takes a much wider range of colony sizes. It collects largely the fast growing *Acropora* species as well as substantial amounts of other genera (Appendix 14.1). The collection is, generally, to order, which targets particular genera. There is good recruitment yearly but much of the specimens taken are several to more than ten years old. Removal of many of the larger colonies allows for the development of corals and other organisms that were being out- competed through rapid growth and monopolizing strategies.

The question remains as to what is a sustainable amount of harvest. As the quantity of material taken is unregulated, the area limited and the market growing , the resource will come under increasing pressure in terms of collection. An initial baseline assessment or resource of the standing crop prior to harvest will provide a basis for assessing the amount of material available and the impact of an annual harvest can be better inferred. Part of the question as to whether sustainable levels of collection are being achieved will be answered through both field inspection and the monitoring of collection records. Unfortunately, monitoring will only keep in touch with the progress of the operation and not provide much in the way of the precise impacts on other fisheries or the ecosystem, generally. The cost and requirement for trained personnel as well as the difficulty of actually doing the monitoring, make management guidelines much more important.

The companies engaged in curio collection are Seaking Trading Co. and Acropora Intn'l operating in operating near Viti Levu Bay (Figs. 25, 26 and in Bau Waters (Figs. 27, 28) respectively.

Following points summarize the main requirements in an environmental impact assessment on the fishery.

These are :

1) abundance of material available for collection
2) growth rate of the species to be removed
3) ability for the coral to re-establish
4) potential for user conflicts

Both companies collect from reefs that are luxuriant, with reef flats that host high coral cover. The material taken is largely of the genus *Acropora* and *Pocillopora* which are fast growing and prolific recolonisers. Collection is limited by the prohibition of underwater breathing apparatus which should prevent collection in deeper water. The decorative nature of the coral requires only attractive pieces, discouraging the collection of damaged or mis-shaped specimens. Larger specimens are not normally collected. In both cases, this is parent material for recruitment.

Waste in the collection of inappropriate material is a problem. In the case of Seaking Trading Co., in its operation near Viti Levu Bay, there are severe management problems with the unregulated collection of material. The amount of material is far in excess of requirements and much of it is damaged and unmarketable.

Another problem is that the amount of material extracted leads to a perception that this activity is destructive and must impact on the catch fishery. In areas where the activity is embraced by the village and the qoliqoli is large, this is less of a problem. In Bau Waters, were the boundaries of the area are more confined and the fin fish fishery is shared by many villages, there is a hesitation by the non-participating villages, to believe that the activity is non-destructive.

The curio trade is the most problematic in its assessment, as conceptually, it appears that over collection may take place. It is for this reason that it is prudent to re-establish an export quota. Additionally the collection areas should be subject to a detailed assessment after the techniques of Grigg (1984) and Ross (1984) in which detailed resource information is collected. From this, an adequate monitoring regime could be developed.

Figure 21: Qoliqoli boundaries representing the collecting areas of Walt Smith Intn'l.

Figure 22: Aerial photographs of reef types and areas within the qoliqoli (Fig. 21).

Figure 23: Qoliqoli boundaries representing the collecting areas of Waterlife Ltd.

Figure 24 Aerial photographs of reef types and areas within the qoliqoli (Fig. 23).

Figure 25: Qoliqoli boundaries representing the collecting areas of Seaking Trading Co.

Figure 26: Aerial photographs of reef types and areas within the qoliqoli (Fig. 25).

9.1.3 Misconceptions

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As some of the objections to the collection of coral reef organisms are based on naïve perceptions, it is important to consider some of the known misconceptions about coral harvesting.

1) Coral harvesting, by its very nature, is the denuding of all the coral on the reef.

This is not the case as the collecting is only of particular species of defined size categories. Of the large number of coral species present, the removal of particular species is difficult to detect if the nature of the reef were not previously known. The problem in assessing the effect of coral harvest is that the composition of the reefs are so variable. The artificial removal of a component of the hard coral from a reef community would still leave an assemblage which would be difficult to discern from the range which results wholly from natural causes. Only a small percentage of the coral on any particular reef is collected. Both the outer crest and the seaward slopes are areas that are not extensively collected due to abrupt depth and wave action. It does not remove the largest colonies or the encrusting colonies. Coral harvest is selective. The vast majority of hard coral colonies are not taken due to their large or small size, unsuitable shape, damaged or diseased colony.

2) Coral harvest or *Live Rock* extraction is the removal of the reef-building material that has the net result of weakening or limiting reef growth and therefore allows the erosion of reefs which threatens the coastal processes.

The resistant nature of the reefs is the result of the consolidation of coral blocks by algae. Coralline algae form the principle component of the outer reef crest, where the cemented margin is host to only the most robust coral forms characterised by little relief. The degree of reef consolidation is a general response to the energy that is vented onto the reef. The seaward front is the most consolidated reef zone where the reef crest is characterised by an algal pavement and buttress system creating an impenetrable barrier against the force of the waves. This zone is ten's of metres thick. With depth, the coral presence increases and becomes more luxuriant. It is in this seaward area that much of the rubble originates that becomes consolidated on the reef flat. Most of the material traverses the reef to be slowly degraded into smaller material and eventually sand.

3) In the process of coral harvest, many other organisms will be collected (pearl shell, trochus and food items).

This is not an issue as it is practiced in the broader spectrum of gleaning generally. Pressure will always be on high value organisms whether from harvesting crews or general fishing. The area harvested is from the qoliqoli in which the resource custodians have the right to collect. Considerations of over-fishing of reef organisms may occur but general fishing pressure minimizes that taken in the course of the coral product collection.

4) Coral collection is likely to cause coral extinction.

The widespread distribution of coral species in the tropical Indo-pacific precludes extinction as a consideration. It is likely that there will be a great reduction of some species in the area of collection. Though a few species are rare and only found in some localities, by and large, the inter-connectivity of reefs through currents, ensures that propagation from deeper water and other reefs. In the Philippines, colonies of the common ornamental coral, *Seriatopora,* were absent from a collected reef when compared with areas where no collection occurred (Ross, 1984). Some species have very limited ranges and are found in restricted areas such as in the eastern Pacific. The coral trade in the Costa Rica may threaten some species (Guzman 1991).

9.1.6.1 Coral Status

The status in terms of species abundance, distribution and recruitment rates of the coral resources is unclear. The term coral applies to hard coral and has been extended to soft corals and coral reef associated organisms in the *live coral* trade. Due to their diversity, it is difficult to make generalizations about the biology and ecology. Our knowledge is often only categorical, with much of the details of their life histories unknown.

The standing stock of coral products for the aquarium or curio trade varies in their species abundance and distribution from reef to reef and zone to zone. Though there may be localised depletion of some species or genera, aspects of recruitment such as a twice yearly "mass spawning" and wide spread current borne dispersal indicate that the depleted stocks will be re-established upon the ceasing of collection. Given the probable wide dispersal of coral larvae, and the many unexploited reefs, which can potentially provide recruitment to exploited reefs, coral stocks in the Pacific will be resilient to extraction. There is no generalised assessment of standing stock, population numbers or species groupings. These figures will only become available through more extensive survey and may best be dealt with on an area by area basis. The life history details of the wide range of organisms now collected will require more basic research before they will be available for fisheries management decisions. The only viable approach to developing this fishery is to substitute the grey areas of our understanding with stricter management and monitoring. At this point in the exploitation of coral resources, the stock can still be considered in abundance. In all cases, there is hypothetically a sustainable level of collection. Whether this hypothetical level equates to a commercial level will remain to be seen during the monitoring phase of the assessment.

Though the export figures are inflated in some areas due to the inclusion of transshipment product, for all coral related products, there has been a consistent increase in the amount of export since 1999. This indicates that there has been ample product available to keep pace with the development of the market. In the case of the *curio* extraction, the figures relate to a localised area but continue to increase despite intensive collection since 1992. The area has a previous history of collection in the area dating back to 1985.

The resilience of coral populations in the face of natural limiting factors such as cyclones (Highsmith et al., 1980) and the crown-of-thorns starfish (Lovell, 1994) is that feature which suggests that managed coral collection may be a sustainable option. Corals generally recruit twice yearly which makes them very adept in re-establishing their populations. During prolific spawning periods the eggs and sperm are distributed widely (Babcock et al., 1985). They develop various strategies in securing their position on the reef. Natural competition is intense but the bottom dwelling organisms have many tactics that allow them to maintain their populations (Bak et al. 1978). A multitude of colonizers is a fundamental theme that allows coral to take advantage of any space made available. Space is maintained through chemical strategies, overtopping with subsequent shading to death, or killing ones neighbor through aggressive attack by using mesenterial filaments.

The rapid growth and re-establishment of many coral species, both hard and soft, provides encouragement that their extraction is sustainable. In the live coral trade, species may be one to five years old . Given the large areas available for collection, it is likely that recruitment will keep pace with harvest. This perception holds for the curio coral trade with the exception that much larger sizes of coral are taken so that many of the specimens are in excess of 10 years old. Large collecting areas are important but the sustainability of the curio trade is based on the abundant presence of unsuitable specimens both in form and protected by depth and areas where collection is not possible, providing parental material for recruitment. In this type of collection depletion of a species is accepted with the

assurance that recolonisation will occur. This is complicated where curio coral collectors are operating in the same area as that of live coral collection. Here all size categories of some species are taken. This is an added pressure on the resource and makes the concept of sustainability more one of removal of abundance with the presumption that if the collection activities cease their populations will re-establish. Unlike the rapid growing branching and table-like species, massive or boulder-like coral, have a slow growth rate (Appendix 14.2) and would take 10's of years to re-establish. Collection of these in New Caledonia from a limited reef area was determined to be 12 times the sustainable level (Joanott and Bour, 1988).

Harvest has been likened to logging in that natural abundance or the standing crop of species are harvested. It is also a perception that all coral has a slow growth rate. This analogy is flawed in most respects for the following reasons. The most popular corals taken are fast growing (Appendix 14.2). The size categories are generally limited to small to medium size colonies with the largest not taken. There is little peripheral problem with damage such as cause in the case of logging through roads and base operation clearance and subsequent erosional problems. Generally there is a yearly spawning in which recolonisation takes place in what is a space limited environment.

The re-establishment of commercial size corals is through the natural process of recruitment and growth rather than husbandry. From a mariculture point of view, the slow growth rate of corals doesn't make economic sense if the option for natural exploitation exists. The question of mariculture and husbandry of coral are now being investigated (see section 11.9).

The consequences of too much coral being removed from an area is the reduction of recruitment by that species. If collection concentrates on particular corals, then the chance of recolonisation becomes less likely by those harvested species unless sufficient non-harvested areas exist to allow recruitment. Sustainability can be estimated (section 11.2) and confirmed through regular monitoring.

For aquarium coral, Green and Shirley (1999) considered concluded that trade in those species known to flourish in aquaria may be sustainable and that trade in other species is probably not. On the basis of the CITES data, it would be more realistic to conclude that, globally, the aquarium products and curio coral trade is a low value business with little long term impact. Baquero (1999) believes sustainability can be achieved through a *chain of custody* approach, the use of *best practice* collecting techniques with a certification and labeling program of management.

9.2 Socio-Cultural Aspects of Coral Harvesting

The opportunity for a village to take advantage of aquarium products or curio coral collecting offers an improvement in the standard of living through employment and a cash income. The ready acceptance of this type of collection may be based in the traditional belief that the reef has always provided for the needs of the village and this opportunity is but another example.

The benefits which are derived from what is considered a common resource gives rise to discontent from those who are not part of the harvesting operation. The destruction of collected coral occurred in the Ra Province as the result of such discontent by elements in the village who wished to be involved in the collecting. Confiscation of vehicles has occurred by villagers who objected to the collecting in their qoliqoli's has occurred in two instances. One was in Ra concerning curio collection and the second was the result of the collectors from Malomalo began collecting *live rock* from the adjacent qoliqoli.

The socio-economic benefits arising from the new fishery are varied. In an economy where unemployment is highest in the village setting, the desire to take advantage of income derived from reef resources is strong. The companies make the business prospect more desirable by offering additional payment to the Vanua or to community projects. The chief who is important in the

decision to proceed with the business receives the largest percentage of the payment for the extraction. He may also be the license holder.

9.2.1 Impacts Of Future Developments and Resource Potential

Potential expansion of the fishery and its likely impacts are reliant on a more complete understanding of the resources. This understanding will be gained over the next two years of monitoring and allow for management adjustments to be made at that time. The current report has recommended that there is no additional entry into the fishery of other businesses during the monitoring period of the next two years. This will allow a more informed appraisal of the impact of the existing firms by providing a time frame within which assessment will be more firmly based on data collected. It will allow the Fisheries Division to develop a monitoring system for the varied coral related fisheries. Before there is additional entry into the industry, the Fisheries Division needs to establish a management framework that adequately regulates the fishery. Existing problem areas such as resolving policy on conflict of multi-users of collecting areas, inadequate record keeping, monitoring and enforcement of guidelines needs to be addressed by the Fisheries Division.

Broadly speaking, the coral related fishery appears to be under utilized in all areas. "Best practice" techniques of collection need to be uniformly employed. Though *curio coral* trade is the most questionable fishery with respect to its ecological impact, it is also a non-perishable product that can be taken from outer islands, transported at convenience, greatly widening the scope for adequate areas for collection. The limits for growth, for all, rely both on the market, the ability to successfully conduct business and the availability of the resource. This latter point is an achievable goal if the resources are available for assessment.

For the *live coral* collection, one of the critical factors is transportation. Once the coral is detached, it is liable to suffer from abrasion during handling, water quality problems such as variations in temperature or oxygen levels. The key to keeping these within acceptable limits is the availability of suitable roads connecting the warehouse facility and subsequently the airport. With out reliable flights, the retail markets are inaccessible. Given this transport equation, the *live coral* trade can only efficiently develop in areas around Viti Levu. Rough sea or road transport would most likely result in unacceptable mortality.

The collection of *live rock* is largely developed along the south coast of Viti Levu. This is because the wave action promotes good coralline algae development. Considering "best practice" methods where collection is confined along the seaward algal crest, there is a substantial resource of relatively low environmental impact that has yet to be utilized. The present problem with the *live rock* trade is that the market price has fallen to the point where its export future is in question.

9.3 Legal

The Fisheries Act of 1992 is a revision of the 1970 Act. Despite improvements in many areas, it fails to include any reference to the collecting of coral or reef products except to consider them as fish. All regulation of the aquarium products and coral harvesting fishery are through the Fisheries Division guidelines on coral harvesting.

9.3.1 Issues

Several issues regarding the Fisheries Act need attention if there is to be regulation of the aquarium products and curio harvesting are:

1) Lack of reference to the industry and its varied components such as the type of product and its collection. This issue must be resolved by developing regulations and amending the Fisheries Act.

2) The system of licensing needs review. The accepted licensing practice is in contravention of the Fisheries Act whereby a single license holder represents a team of collectors. Some licenses issued for general commercial fishing has been utilised for live coral collection. The present system conveys the right to fish a resource common to the Vanua, to a single person. Though illegal in terms of the Act, this practice empowers the license holder to control both access to the resource and the employment in utilising what is an asset common to the Vanua.

With the other fisheries, it is the fishermen who are licensed. In the case of aquarium and curio products, it should be the entrepreneur who accepts responsibility for the collection and is responsible for the activities of the collectors.

3) Lack of empowerment of the Fisheries Division within the Fisheries Act to regulate the industry through punitive powers remains a problem. At present, the withholding of export permits through an arrangement with the Customs and Excise Department represents the principal means of control of management of the industry. The Fisheries Division may be liable to litigation by the entrepreneurs through the illegal prevention of export in a manner not prescribed by law.

4) It is presumed that the Fisheries Division is responsible for licensing the coral harvesters whose product is destined for export or the domestic market. In the present system, the Custom Department acts as agents for the Fisheries Department who issue the export permit. The legal basis for its role in regulating export has yet to be defined. An export licensing system could be used to implement conservation/management measures. But regulation authorizing such a licensing system does not exist. Provisions in the Fisheries Act (Section 9) allow the Minister to use his decretionary powers to regulate any matter relating to the conservation, protection, and maintenance of a stock of fish. This should be used to broaden the Act to establish a legal basis for the responsibility for export permits (Gillett, 1995).

Licensing and export permits should be subject to fees. This revenue could be used to assist the Fisheries Division in managing the fishery, particularly in the case of monitoring.
Licenses should attract a fee of $500 and the issue of export permits $25.

5) With reference to the Coral Harvesting Guideline no. 14 which states, “The failure to abide by the above guidelines will automatically result in the cancellation of the fishing license”. This should also state that there will be a withholding or cancellation of export permits as only through export permission will control of the operators be achieved. This is because the operators contract the villages for collection and the license holders are in the village. The custodians are not subject to most of the guidelines, which refer to requirements for the entrepreneurs. The guidelines have frequently been ignored particularly with respect to the Fisheries Division requirement for notification of establishing new areas of collection. Environmental impact assessments are rarely conducted . Punitive consequences are not employed. Management is crucial to the success of the industry. Not to manage it is to jeopardize its existence. A management committee within the Fisheries Division should be standardised to remedy the lack of attention.

6) The lack of clarification of the rights of the custodians with regard to the decision to take advantage of the fishery. It is unclear whether the Fisheries Division has the legal

right to prevent collection in the qoliqoli. This area is dealt with in Section 8.1. It is important to establishing the relative roles within the Dual Tenure System. Management relies on consistent policy and an understanding by all parties as to who is in charge of this important resource.

7) The practice of export of giant clams contravenes 1988 Cabinet Guidelines on *Tridacna* export. Guidelines were formulated by the Fisheries Division and passed by Cabinet in 1984. They put the decision to exploit the resource into the hands of the local qoliqoli custodians, the Fisheries Division role was to keep track of harvesting and provide management advice.. Many of the Guidelines were superseded in December 1988 when Cabinet passed a new regulation banning the export of giant clam meat. Regulation 25A of the Fisheries Regulations (Cap.158 as amended) provides that, "No person shall export from Fiji Tridacna clam (giant clam) (vasua) flesh, including adductor muscle or mantle tissue of the following species:- (a) *Tridacna derasa* (vasua dina), (b) *Tridaca squamosa* (cega), (c) *Tridacna maxima* (katavatu)."

9.4 Economics

The industry provides financial benefits for both the villages and the Government. The new fishery provides employment within the village and may provide other cash inputs such as contributions to community projects. Taxes are paid to Government via income, VAT, and company tax revenues. The export of these items generates foreign exchange capital. For some of the operators, the Fiji Trade and Investment Board (FTIB) have provided a number of incentives to encourage the companies to move their operations to Fiji.

The increasing demand for coral reef aquaria increases an awareness in overseas markets of the wonders of the coral reef environment. With Fiji developing a pro-active approach to developing its tourism markets, the increasingly common coral reef aquarium is a great ambassador. This is particularly so with the origin of the products associated with Fiji. *Fiji Live Rock* has a good reputation and is a preferred product for natural habitat in aquaria.

10.0 REGULATION OF CORAL COLLECTION IN OTHER COUNTRIES (adapted from the SPREP guidelines, Wells et al. 1994).

10.1 New Caledonia

Coral harvest is authorised on one reef only. Fourteen genera and the family Faviidae may be collected under permit. Exploiting other species and from other areas is prohibited. There is an annual quota of 30 tonnes for the family Faviidae, and for these corals, colonies of less than 25-cm diameter may not be taken.

Coral harvesting for all species is prohibited between October 1st and 31st December. Non-commercial harvesting is permitted for the genera *Acropora* and *Fungia* only; *Acropora* must exceed 300gm in weight.

10.2 Vanuatu

Coral harvest is covered in the Fisheries Act of 1982 and subsequent Fisheries Regulations order No. 49, 1983. It limits the taking of coral to three pieces in any period of 24 hours, except by permission from the Department of Fisheries. Permission to export is required from the Ministry of Fisheries.

10.3 Australia

All removal of coral in the Great Barrier Reef Marine Park is regulated by both Commonwealth and State legislation. For commercial coral harvest, it is restricted to licensed areas of the reef front (about 400m long). Additional permits are required for the Great Barrier Reef Marine Park within zoned sections of the Park; commercial collecting is only allowed in zones designated for general use.

10.4 Philippines

In 1976, imports from the Philippines to the United States represented 67% of the US market. By Presidential decree, coral export was banned in 1977 and 1980. Prior to that there had been large-scale removal of coral from the reefs. For 7 months prior to that decree, over $2 million worth of coral was exported (M^{c}Manus 1980). This prohibition has been lifted for a few months at a time. Restriction on collection exist. By 1993, fewer than 500 pieces of coral were exported.

10.5 Federated States of Micronesia

In Kosrae State approval is pending for regulations stating that coral may not be removed without written authorization from the Director of the Department of Conservation and Development. Each State has it's own regulations which differ to varying degrees.

10.6 Guam

Live coral may not be removed from a depth of less than 10 fathoms, and corals may be collected only with an appropriate permit. The depth provision effectively eliminates the curio trade on the basis of abundance and accessibility.

10.7 USA

The Lacey Act is a federal law prohibiting the import of listed wildlife illegally collected or exported from its country of origin. Coral harvest is regulated by legislation covering marine resources within three miles of the coast.

10.7.1 Hawaii

Commercial collection of live corals in the Order *Scleractinia* and, importantly, any rock with marine life attached, is prohibited under State Law (1991) unless a scientific permit is issued.

10.7.2 Florida

Various licensing and regulatory agencies

10.8 Sudan

Prohibition of the export of marine ornamentals.

10.9 Sri Lanka

Halted trade in coral but not in aquarium fish

10.10 Kenya and Maldives

Have various licensing and regulatory systems.

10.11 International regulation: Convention On International Trade in Endangered Species of Wild Fauna and Flora (CITES)

> All stony coral species are listed in Appendix II of CITES. This is due to their ecological importance as a group in the reef ecosystem and the difficulty of identifying them to species .
>
> Listing on CITES Appendix II does not ban the trade, but requires accompaniment of the shipment by an export permit from the country of origin. This allows monitoring of the international trade through a permit system. Importing countries, signatory to CITES, are obliged to honour national legislation such as export bans in exporting countries.
>
> Tourists need a permit to export souvenirs. Import as well as export permits are required by some countries in the European Union (Wells et al. 1994).

The purpose of placing coral on the CITES list has to do with endangering the habitat/fisheries role that coral plays in the ecosystem (Wells et al. 1989). The listing is a response to the wholesale removal of coral from reefs in the Philippines. There are corals that are considered rare but these are naturally rare and no particular species is being considered threatened with extinction as the result of coral harvest. Local extinction is a possibility (Guzman 1991; Ross 1984). As collection in some cases is from discrete areas such as relatively small qoliqoli's, the localised depletion is likely for some organisms though were collection to cease, it is probable that their populations would re-establish.

10.11.1 CITES in Fiji

Fiji became signatory to CITES in the April of 1998. The Ministries of Environment and that of Agriculture, Forests and Fisheries officiate CITES verification. All coral products exported to the United States require a CITES documentation. Other CITES member countries particularly those in Europe require a clearance from the country of origin in advance. The Fisheries Division officiates the aquarium products export. The Environment Department is responsible for liaison with line Ministries and the monitoring the status of the resource. Though this latter responsibility involves the collecting of statistics on the export of the CITES listed species, this is not happening.

11.0 OPTIONS FOR THE FUTURE MANAGEMENT AND USE OF CORAL REEFS IN FIJI

> " There is great pressure on government fisheries departments to put formal plans in place to ensure sustainable coastal fishery management without either being able to monitor the status of most coastal fisheries, or even know what level of exploitation is actually sustainable.
>
> Management of coastal resources such as aquarium products and curio coral collection must rely on the understanding of the potential problems in utilizing the fishery and the acceptance of provision and evolving management plan until more is known about how these fisheries are likely to respond to regulation. Also, it is important to try to accommodate the attitude of established coastal communities towards the resources under their control, unless assessment clearly shows that there attitudes are ultimately self destructive, or destructive to others " (Adams and Ledua, 1997).

Ideally, future management of coral reef use will achieve sustainable use with minimal user conflict or disadvantage. Sustainable use is the goal of management by the Fisheries Division and the custodians. The two interests have a different emphasis in that the latter has a more practical

relationship with the resource in which there is an emphasis on the maximizing the tangible rewards. In the absence of a full understanding of the consequences, the custodians may be willing to engage in reef products collection. This, with the view, that if problems present themselves that outweigh the benefit, then the activity can be stopped. The reef has always seen to be resilient, particularly in recovery from cyclone damage and so it is likely to restore itself if coral collecting activities seem unacceptable and are halted. Part of the management problem is whether the collectors might impact on other village reef users who receive no benefit from the enterprise.

11.1 Coral Reef Management Plan

It is because of user conflict between general development, tourism, fisheries and conservation groups that a coral reef management plan is desirable. Unlike other countries whose subtidal areas are wholly the province of the State, Fiji has a duel governance in which the custodians have the right to regulate some fishing activity but in effect exercise user control in many cases. A management plan would only be possible if the custodians were involved in its development and there was clear benefit to them. This constraint has been one of the principle barriers in preventing the establishment of marine protected areas or marine national parks.

Given that *de facto* management of the qoliqoli reef areas resides with the custodians, the responsibility and consequences also resides with them. In partnership, the role of the Fisheries Division has become one of supporting the fishery through working with the custodians to determine the best way of managing the resource and providing awareness and expertise in its assessment.

11.2 Criteria To Determine Sustainability of Collection of Hard and Soft Coral.

Following are the requirements and procedures for determining sustainability of live coral collection.

a) Determine categories of corals that are to be taken. What are the target species and growth forms and sizes?

b) During the baseline study, estimate the sustainable yields for the species most likely to be taken (after Grigg 1984). Use this to determine quotas based on categories. This would involve detailed inspection of information on distribution and abundance, growth rate, and rates of mortality and recruitment (based on colonial diameter measurement).

c) Quotas will be determined on the basis of:

i) the relative abundance of coral species present or numbers of genera or some broader category

ii) the corals growth rate

iii) size classes should be assessed to determine recruitment rates.

iv) nature and size of habitat to be collected and proximity of adjacent reefs

d) Monitoring should occur with a frequency to be determined by the scale of collection. It should be based on the criteria above.

i) Design the original resource survey so as to be able to collect subsequent data for comparison and analysis.

ii) Establish reference or control sites in the collecting areas.

iii) Survey the collection areas with respect to estimates of the categories abundance and nature of assemblage (video, photography, and general description).

iv) Develop a collection strategy so that the collection areas are known as to their history of harvest.

v) Records are to be kept by the collectors as to the amount of coral being taken from a particular area.

An example of surveying the coral resource was conducted by Joanott and Bour (1988). In this study, the biomass of the coral for the family Faviidae were assessed in determining the level of commercial extraction. This survey may be adapted to other coral species. Following are elements of the method..

A survey is conducted which will allow the numbers of particular types of corals to be known. This is by manta towing if the amount of material being assessed allows or by the line transect method if a sample is sought. The sample should allow a portion of the reef to be assessed for absolute numbers. It should comprise size classes of the particular species. The purpose of the size classes is to determine age categories. The size classes will vary with respect to the species. The size classes may be as few as three, depending on the information required and the resources available. The dimension taken should reflect its likely age (i.e. half the diameter of the massive or table coral). For the monopolizing branching corals covering broader areas, a sample of branch lengths and the spatial extent and the number of areas should to be determined.

"…It doesn't require an intimate knowledge of the biology of a target species in order to manage a fishery- in simplistic terms this can be accomplished by reducing exploitation if catch rates start to fall – it definitely does require feedback from the fishery on catch rates…" (Adams and Ledua, 1997). Unlike other fisheries, the goal of good monitoring is achievable as the type of material or species are recorded. The effect of *Live Rock* collection is localized and observable through a limited program of monitoring. Collection of live and curio coral areas are known as are the species and their numbers that are collected from through the CITES documentation. Analysis of the levels of export at the species level will reveal whether the depletion of product is occurring. The management plan must be flexible enough to initiate remedial action such as imposing quotas

11.3 Resource Survey

A resource survey involves assessment of the amount of the standing crop of the target species. Part of the description or survey of this resource is an assessment of the exploitable area. Exploitable area is that portion of the reef which is available for collection. The portions of the reef suitable are assessed with a general comparative understanding of the whole reef. Representative areas are then sampled as to the species and abundance.

The quantity of the species is important but also a comparison with adjacent areas that are likely sources of recruitment. Biotope suitable for the growth should be assessed by the use of bathymetric information and aerial photography. Some areas are intertidal whilst other areas are too deep and considered poor for collection. The exposed and protected nature of the reef is important in determining particular abundance. The areas should be mapped as to the communities to be exploited, noting areas to be protected from collection.

11.4 Stock management plan

Maximum sustainable yield (Brouard and Grandperrin, 1984) can be calculated through the use of the parameters of known exploitable biomass and mortality (Gulland, 1969). This method was used to assess the Faviidae stocks being harvested in New Caledonia. It showed the stocks to be limited. "With the present rate of exploitation, which is twelve times higher than the maximum sustainable yield, there is a real danger of Faviidae becoming extinct on this reef which is the only one where the harvesting of corals is authorised (Joannot and Bour, 1988)". This family is a massive or boulder-like coral with a relatively slow growth rate. Apart for the harvest for septic systems in Suva, this type of coral is not allowed for collection in Fiji, except through special permission from the Fisheries Division.

Similarly, Grigg (1984) used the classic fisheries population dynamics model of Beverton and Holt (Beverton & Holt, 1957) to assess the status of the deeper water, precious coral fishery. Using data from Ross (1983), he applies the same techniques to hard coral. Initially, the data was used to develop a relation between size and age. Data for size and weight was used to determine the equation for size versus weight. The instantaneous rate of natural mortality for *P. verrucosa* was calculated by regression of year class data versus time for the unfished population. The product of survival at year (x) times mean colony weight at year (x) was then calculated to produce an estimate of yield per each year. In comparison with the fished population, it was determined that the fishing of the resource was close to maximum sustainable yield with colonies less than 6 years old rarely harvested.

Grigg (1984) quotas can be adapted to species categories. This would involve detailed inspection of species information on distribution and abundance. The procedure would entail conducting a survey confined to the qoliqoli where reliable survey techniques would sample the species composition.. Growth rates are known for many species and with good confidence at the generic level. Rates of mortality and recruitment are determined from colonial diameter measurement. Problems which confront the use of this method are the large areas which are available for exploitation making adequate sampling a substantial task. The discrete reefs adjacent Viti Levu Bay offer the best opportunity to employ these methods

11.5 Allocation of Fishing Areas : an essential conservation tool

Perhaps the most serious conservation concern is the presence of multiple operators in the same area, competing for the same resource. With the objectives of Fisheries management prioritizing sustainability through conservation and operator responsibility, the competition for marine products by multiple collectors has the potential to be devastating to the resource. With commercial concerns taking priority over the conservation and rational management of the resource, the whole concept of sustainability becomes in doubt.

With the industry in it's infancy, it is appropriate to enforce the convention *of one operator, one collecting area* which has been part of the precautionary approach of Fisheries since the first coral harvesting operation by Seaking Trading Co. A recent allocation of areas by the Deputy Permanent Secretary of the Ministry has reaffirmed the practice for *live rock* areas. It is essential for the successful development of the aquarium products and curio industry, for control by Government to be consistently implemented in this area. Not to do so would compromise both management and monitoring as accountability for the resource and the reef becomes unclear.

At this stage, rights to collecting areas are being obtained by collectors, who seek only permission from the custodians and are violating the Coral Harvesting Guidelines for the Industry for guideline numbers:

(1) concerning prior approval with the Fisheries Division
(2) not conducting an environmental impact assessment

(3) no demarcation of area by the Fisheries Division
(4) lacking a formal strategy for collection
(7) lack of notification of utilising a new area..

Fortunately, there are ample collecting areas at present in Fiji. The advantages of single operator allocation of areas are:

1. The ability for the operator and custodian to manage the resource. With the nature of the resource known, a rational collection program can be implemented. Areas of collection may be rotated to preserve stocks.

2. Accountability is not possible when multiple companies use the same area. Problems of damage, over-collection or infraction of the recommended guidelines or regulation are more difficult if not impossible to deal with when there are multiple users of the same resource.

3. Operators who find employees culpable of poor practice or who are chronic offenders of proposed Fisheries regulations are unacceptable employees but in a multi company environment would have the opportunity to seek employment with the competitor. This is particularly so as they know the resource area and the strategies of the competitor.

4. Conservation is encouraged for an area so it will remain productive in the future rather than a strategy of encouraging over- and inefficient collecting with the mentality of "get it before the other guy". With two operators, the commercial reality will minimise conservation efforts as the product will always be threatened by the competitor.

5. A company that has security of operation in an area is able to provide secure employment which allows employee's to be trained in "Best Practice" and develop their own life, in terms of housing and family with a future in a reliable, cared for resource.

6. Some mechanism needs to be developed whereby the custodians are justly compensated rather than letting the financial incentive of the short-term market, where the resource is quickly exhausted or damaged by unregulated use, prevails. The Native Land and Trust Board manages the land rent, so a similar government body should officiate revenue given for exclusive access to the Customary Fishing Rights Areas.

11.6 Penalty for violation of Fisheries Guidelines.

A regime of fines are recommended for non-compliance with the Fisheries Guidelines. Consequences for the breaching of the guidelines, at present, is confined to the withholding of export permits. Regulation through punitive fines is an additional incentive to adhere to the guidelines.

Penalty fee structure to be levied by the Fisheries Division for non-compliance with Fisheries Guidelines* or regulations:

Lack of application to Fisheries Division for permission to engage in an extractive activity $5000

Not engaging an environmental impact assessment and resource survey $5000

Collection activity outside of the approved area $1000

Collection not adhering to a collection strategy plan..... $ 500

Lack of field record keeping concerning the product removal..... $ 500

Operational:

Use of Underwater Breathing Apparatus (except with Fisheries Division exemption and divers certification) $5000

Needless habitat destruction..... $ 500

Use of explosives……..$10,000 and suspension of license

Live coral collection:

Collecting protected species..... $ 100

Excessive waste of collected material..... $ 500

Export permit inconsistencies..... $ 100

Adherence to established species size categories..... $ 100

Breaking up of larger colonies..... $ 500

Curio Coral Collection:

Collection of coral specimens excessive to product flow criteria or $5/ specimen which ever is greater $1000

Collecting protected species..... $ 500

Excessive waste in terms of damaged specimens $1000
..... or $5 per specimen which ever is greater

Live Rock:

Damage to parts of the reef flat not used for collection or specified in the resource survey as protected $1000

Waste ..... $ 500

*Regulations to be defined by the Fisheries Division committee in consultation with the Aquarium Traders and Curio Coral Council.

11.7 Industry Association: Aquarium Traders and Curio Coral Council

A more effective way of regulating the industry is through consultation with Industry, Fisheries Division and the Environment Department. The Aquarium Traders and Curio Coral Council resulted from a Fisheries Division meeting (15/4/98) in which the Industry participants sought to assist the Fisheries Division in development and management of the fishery. An interim Chairman has been elected and periodic meetings have been held though its constitution has yet to be ratified.

11.8 Standards Association for Aquarium Products Collectors: The Marine Aquarium Council - certifying quality and sustainability in the marine aquarium industry (Text by Paul Holthus, Executive Director, Marine Aquarium Council)

Self-management by the operators of the Industry is one of the goals of fisheries management. This section is about the setting up of a mechanism whereby Industry participants are held accountable to standards.

What is the Marine Aquarium Council?

The Marine Aquarium Council (MAC) is a non-profit organization composed of representatives of the aquarium industry, hobbyists, conservation organizations, government agencies, and public aquariums - all with a shared interest in the future of the marine aquarium industry, the marine organisms it is based on, and the habitat that supports them.

The goal of MAC is ensuring a sustainable future for the marine aquarium industry, organisms and habitat through market incentives that encourage and support sustainable practices.

MAC will accomplish this by establishing standards for “best practices”, developing an independent system to certify compliance with these standards, and creating consumer demand and confidence for MAC certified organisms, practices and industry participants.

Participation in the Marine Aquarium Council continues to be open to those ready to collaborate and contribute to a constructive dialogue and the development of market incentives and a certification system to achieve the MAC goal.

Where did MAC come from?

A cross section of organizations representing the aquarium industry, conservation organizations, public aquariums, hobbyists and scientists began meeting in 1996 in response to shared interest in:

- addressing concerns about the effects of destructive fishing and poor handling practices on coral reef fish and habitat;
- developing a market for marine aquarium organisms supplied through certified sustainable practices based on consumer demand and added value for certified organisms;
- maintaining livelihoods and income generation of rural aquarium fishermen through a sustainable marine aquarium industry; and
- increasing marine conservation awareness and action within the industry and among marine aquarium hobbyists and the general public.

Out of these meetings, the foundations for the Marine Aquarium Council emerged (initially called the Marine Aquarium Fish Council). From this broad coalition, an Interim Board was created to provide for more consistent, focused action toward realizing the MAC goals. The Board formed a series of technical committees to begin work on issues such as standards, monitoring, and education; hired an Executive Director as of June 1 1998; and has incorporated MAC as a non-profit organization.

The Board is currently composed of representatives of: American Marinelife Dealers Association, American Zoo and Aquarium Association, International Marinelife Alliance-Philippines, Ornamental Aquatic Trade Association, Pet Industry Joint Advisory Council, Philippine Tropical Fish Exporters Association, Quality Marine Inc, The Nature Conservancy, and World Wildlife Fund.

How does MAC operate?

> The importance of what MAC is working to achieve, its innovative basis in market mechanisms, and the broad base of participation has led to the active interest and initial support of a few funding organizations for the initial development of the certification system in pilot areas. In Hawaii, an initial prototype set of collecting and handling guidelines has been developed through a series of multi-stakeholder workshops and similar efforts will soon be underway in the Philippines and a South Pacific pilot area to be identified. MAC will continue a phased process of multi-stakeholder consultations to finalize the initial standards, test them in collection-to-retailer operations in pilot areas, and launch the certification/labeling system in 1999.

It is envisaged that the MAC organization and process, when fully established and mature, will evolve into a largely self-financed system based on the improved economic return from certified marine aquarium organisms. In the meantime, external funds continue to be sought for the initial stages of establishing MAC, e.g. to support the development and testing of the certification system, to train fishermen in sustainable collecting and handling methods, and to conduct awareness raising among the consumers and industry.

What does MAC mean to stakeholders in the marine aquarium industry?

The Marine Aquarium Council offers the opportunity to:

- Participate in developing and implementing a certification and labeling system;
- Exercise greater control and management over the animals and habitat upon which the industry is based;
- Provide a quality-controlled, value-added product to the consumer;

- Benefit from a program to create consumer interest in, demand for, and recognition of organisms supplied through MAC certified sustainable practices; and
- Be a part of a forum for the industry and its partners to address the opportunities, future and growth of a sustainable industry.

The Marine Aquarium Council is committed to achieving its goal of a market-based system in support of a sustainable marine aquarium industry.

11.9 Coral Mariculture

A recent analysis of CITES data showed that the amount of cultured coral (coral bred in captivity) being traded internationally is tiny, much less than 1% of the annual total, in terms either of weight or numbers of pieces (Green and Shirley, 1999). Whilst, for a variety of reasons, some trade in coral may not be recorded by CITES permits, it would appear that culturing schemes have a long way to go before they can supply coral in quantities which are significant compared to those harvested directly from the wild (Green, pers. Comm.). Mariculture through artificial propagation is popular among aquarium enthusiasts and is being developed commercially in the Solomon Islands and in Fiji.

The Waikiki Aquarium in Hawaii has been pioneering in the husbandry and propagation of coral. This public aquarium has been very successful in cultivating hard and soft corals (Yates and Carlson 1992). It has colonies between five and ten years of age (Atkinson et al.,1995). This aquarium has distributed 780 fragments in 1997 and 505 in 1998, although it had more orders than could be processed (Green and Shirley, 1999). Jean Jaubert, director of l'Observatoire Oceanologique Europeen de Monaco, has looked at the possibility of culturing various species of corals in aquaria. (Jaubert, J et al. 1996).

11.9.1 Industry efforts

Walt Smith Inter'l is attempting to grow corals on racks at Naviti I, Yasawas. He also has plans and is seeking funding to double the size of his warehouse facility to begin the mariculture of selected organisms. A mariculturalist is being sought to oversee this operation.

11.9.2 Co-operative: a village based industry

The opportunity exists for the mariculture of hard and soft corals and other marine organisms in the waters adjacent the village. As with the seaweed culture *Echuema,* corals and other organisms may be cultivated and sold to the exporters or exported directly, perhaps through a Co-operative arrangement. The Foundation for the Peoples of the South Pacific are supporting Experimental cultivation of coral is occurring near Kamba in Bau Waters at the village level and have plans for expansion to other locations in Fiji..

11.9.3 Liaison with the University of the South Pacific (USP) marine science graduate program.

Employment of post-graduate students to engage in studies that would benefit both the aquarium products industry and satisfy the students degree requirements have been discussed . Professor South Director of the Marine Studies Department at USP has welcomed the interaction between the University and the Industry. Walt Smith International and Ocean 2000 have both offered support for the degree program in terms of logistic and financial support for research topics which are mutually beneficial. These investigations would broadly entail such subjects as the biology of the organisms collected and problems confronting the Industry.

11.10 Summary

Coral harvest in Fiji has been largely a working experiment in which collecting has been allowed on the premise that there is sufficient coral stocks to allow removal that will not adversely affect the ecosystem. The fact that many corals have a high growth rate and observation that reefs can respond rapidly by recolonisation after cyclonic devastation, gives credence to the belief that there is a sustainable level for coral harvests. The work of Ross (1983), Grigg (1984) and Joannot (1988) lays the framework for a valid assessment of levels of sustainability for any coral species. Monitoring of the harvesting areas is an integral requirement of assuring that collection is controlled and damage is minimised. Without a detailed assessment of the resource, the amount of harvesting is liable to err, perhaps dramatically. Monitoring is equally important to assess whether the harvest is at sustainable levels, and whether the reef is being over-harvested.

Organization within the industry through the Aquarium Traders and Curio Coral Council is an important step. As well, certification through the Marine Aquarium Council will allow the implementation of standards which will keep pace with the industry as it develops.

12.0 RECOMMENDATIONS FOR ACTION

General recommendations for management of the aquarium products collection and coral harvesting are listed. Additionally, particular portions of the industry are dealt with individually as the practices vary widely in methods and impacts on the environment.

12.1 Actions and Guidelines

1) To create a Management Committee within the Fisheries Division that oversees all policy of the aquarium products and coral harvesting industry. This committee should comprise individuals who have experience with the industry. Preferably they would be Senior Fisheries Officers, Fisheries Officers or those who have had special training or experience in this area.

2) Data should be collected by the Fisheries Division to include only the products actually exported and not the hypothetical permit allocation. All trans-shipped material from other countries must be designated as such.

3) Unit recorded should show both pieces and weights. For the live coral exports an estimate using 200g/piece as a conversion factor is appropriate where direct weighing is impractical. For the curio coral trade, 500g/piece is to be used if unit conversion is necessary, but direct weights should be taken for the export records.

4) Data should be collected for the export of non-coral species which could be used in the monitoring of the resource.

5) All collecting operations should be subject to an environmental impact assessment and criteria for sustainability (section 11.2).

6) As part of the environmental impact assessment requirement a *Resource Survey* should be required, detailing the extent and abundance of the product to be taken and denote areas and species to be protected. Areas of conservation significance should be described for protection.

7) To be required as part of the EIA, is the submission of a *Collection Management Plan* with provision for record keeping, during the harvesting operation, for monitoring purposes.

8) Monitoring should be carried out on the harvested areas by the Fisheries Division personnel to ensure no obvious detrimental effects. The export data should be analysed as part of the monitoring program to determine the status or availability of products and alert the Management Committee if there is evidence of depletion.

9) Limit one collector per collecting area (this may be one or several qoliqoli's).

10) Limit the number of operators to the established firms until good confidence exists that the fishery is being managed adequately.

11) Provide awareness to the custodians of the customary fishing rights areas as to the nature of the collecting activity. It is important to point out the limits of knowledge and potential hazards that need to be weighed in assessing whether to engage in the harvest activity.

12) Utilize the *Sea Warden* system of nominate a Fisheries contact person in the village, who is responsible for overseeing the operation with respect to the Fisheries Management Guidelines and regulation.

13) In consultation with industry, establish guidelines as to 'best practice' for the type of collecting (live, curio, rock) for a particular area.

14) Require certification of collectors and exporters by the international Marine Aquarium Council.

15) Provide a post-graduate program subsidy with Marine Studies at the University of the South Pacific, whereby the collectors of aquarium products provide financial and research support to investigate the biology of the organisms collected and problems confronted by the Industry.

16) The Fisheries Act should be amended to provide a legal basis for the issue and control of export permits by the Fisheries Division.

17) A system of fines for non-compliance to the guidelines or regulations should be established.

18) Fees should be charged for both licenses and export permits. The funds derived from this should be used to support the Fisheries Divisions support of the industry through monitoring and research.

19) Operators should contribute to the cost of the monitoring programs.

12.2 Collection of live coral and other living reef creatures

1) In consultation with Industry, establish size limits for all organisms.

2) Collection of whole colonies only with the fragmenting of larger colonies prohibited.

3) Require a commitment by industry participants to the mariculture of aquarium organisms

4) In consultation with Industry, place quotas on the animals known to be rare (i.e. large anemones: *Heteractis spp.; Macrodactyla spp*.) or organisms that are very difficult to keep in captivity (i.e. carnation coral: *Dendronephthya spp*.) Develop a separate study, in consultation with the operators, to determine which organisms are rare or unacceptable for collection.

12.3 Collection of *Live Rock*

1) Confine collection to the seaward margin of the lagoon and algal crest.

2) Select areas where diversity and reef flat topography are naturally limited by periodic river outflow.

3) Avoid collection in areas of good coral cover such as in lagoonal areas.

4) Utilize only a portion of the qoliqoli.

5) Return waste rock to a reef holding area to allow further colonization.

6) Discovery of additional *live rock* resources to be subject to an environmental impact assessment and Fisheries Division approvals.

12.4 Collection of Curio Coral

1) Collect only enough product for processing and dispatch in a timely manner.

2) Waste of material collected will be subject to a regime of fines. The term *waste* to be defined by and fines decided by the Fisheries Division in consultation with the Aquarium Traders and Curio Coral Council.

3) Establish a quota system based on the resource assessment methods by Grigg (1984) and Joannot and Bour(1988).

4) No coral to be collected over a maximum diameter of 45 cm.

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14.1 Taxonomy of coral species and their common names as collected by the curio trade

(taxonomic list after Viala, 1988 and Lovell, this report**)**

Table 4: Taxonomy of coral species with equivalent curio trade names

Taxonomy		Trade Name
Phylum	Cnidaria	
Class	Hydrozoa	
Order	Milleporina	
Species	*Millepora platyphylla*	Fire
	M. tenella	Fire
	M. exaesa	Fire
Class	**Anthozoa**	
Subclass	**Alcyonaria**	
Order	**Stolonifiera**	
Species	***Tubipora musica***	Pipe organ
Class	**Anthozoa**	
Subclass	**Zoantharia**	
Order	**Scleractinia**	
Species	*Acrhelia horrescens*	Bermuda
	Acropora austera	Staghorn
	Acropora arcuata?	Small branch
	A. cuneata	Cat's paw
	A. echinata	Pine tree
	A. elseyi	Pinetree
	A. formosa	Staghorn
	A. grandis	"
	A. humilis	Finger, pyramid
	A. hyacinthus	Table
	A. longicyathus	Pinetree
	A. nobilis	Staghorn
	A. palifera	Catspaw
	A. prostrata?	Table
	A. robusta	Staghorn
`	*A. secale*	Table
	A. subglabra	Tree
	A. vaughani	Table
	Most Acropora are collected	
	Agaricia tenuflora?	Mushroom (?)
	Dendrophyllia micranthus	Octopus
	Diploastrea heliopora	Brain
	Echinopora lamellosa	Lettuce, Rose, Medusa, Star Merulina
	Euphyllia divisa	Divided brain
	Fungia concinna	Mushroom
	Fungia echinata	Slipper
	Faviidae: Favites and Favia spp.	Brain
	Galaxea fascicularis	Tooth, Cauliflower
	Goniastrea spp.	Brain

Goniopora columna	Finial
Halomitra pileus	Bowl
Herpetolitha limax	Slipper
Hydonophora rigida	Lakari
Leptoria phrygia	Closed brain
Leptoseris fragilis?	Glass
Lobophyllia corymbosa	Open brain
Lobophyllia hemprichii	-
Mendusa? *Korei?*	Korei
M. lakeri?	Lakeri
Merulina ampliata	Merulina
Merulina spp.	Star
Montipora sp.	Poca
Montipora striata	Montipora
Montipora spp.	Bermuda
Pachyseris rugosa	Rugosa
P. speciosa	“
Pavona frondifera?	Lettuce
P. lata?	Cactus
P. cactus	Cactus, Lettuce, Glass
P. decussata	“
Pectinia lactuca	Lettuce
Pectinia spp.	Cluster
Pocillopora damicornis	Brown stem, cluster, lace
P. eydouxi	Cauliflower
P. verrucosa	
Porites spp.	Porites
Platygyra lamellina and others	Brain
Sandalolitha spp.	Cup
Seriatopora hystrix	Birds nest
Stylaster spp.	
Stylophora pistillata	Elkhorn
Stylophora spp.	Black elkhorn
Tubastrea micrantha	Octopus
Tubipora musica	Pipe organ
Turbinaria mollis?	Rose/cup
Turbinaria mesenterina	Cup
Turbinaria peltata	“
Turbinaria spp.	Frond
Zoopilus echinatus	Big cup

(?) indicates invalid species names

14.2 Coral Growth Rates

Corals as a group have a wide range of growth rates. The rate variable between 0.4 and 22.5 cm per year. (Buddemeir and Kinzie, 1986). The massive corals grow more slowly with a range of 0.4 to 1.8cm. (DeVantier, 1993).

Growth rates of the massive corals measured in Australia at approximately the same latitude provides information on the growth rates of the coral in Fiji.

Table 5: Growth rates from the Great Barrier Reef Region of corals harvested in Fiji.[1]

Family || Genera	Range of Growth for Family[2] (cm)	Remarks: Colonial form and use
Faviidae *Favia* *Favites* *Goniastrea* *Montastrea* *Platygyra*	0-1.38 Mean range .07-1.25	Massive or rounded coral with large corallites (includes brain corals) Used for lathe worked ornamentals (ex. lamp bases) Live coral exports
Poritidae *Porites* *Goniopora*	0-1.88 Mean range .13-.97	Massive or rounded corals with small corallites Used for medical purposes in bone reconstruction Live coral exports
Mussidae *Lobophyllia* *Symphyllia* *Acanthastrea*	0-1.65 Mean range .38-.94	Rounded with large corallites Live coral exports Ornamental
Oculinidae *Galaxea*	.67-1.18 Mean range .54-.93	Massive or encrusting with spiky corallites Curio and live coral export Ornamental
Merulinidae *Hydnophora*	.56-1.15 Mean .86	Massive or rounded Curio and live coral export
Caryophylliidae *Physogyra* *Euphyllia*	.5-.75 Mean range	Massive with fleshy corallites.

Pierogyra	.3-.73	
Acroporiidae[3] *Acropora*	10.17-22.58	Branching to varying degrees, though some form plates or brackets Principal genus utilised for the Curio and live coral export
Pocilloporiidae[3] *Pocillopora*	.4-3.59	Colonial form branching but not as expansive as most of the Acropora, more clumped Curio and live coral export Principal genus harvested in Australia

1. DeVantier, L.M. 1993.
2. 0's reflect no increase in diameter. This is often due to injury.
3. Buddemeir, R.W. and Kinzie, R.A. 1976. Records not from the Great Barrier Reef.

14.3 Specimen Prices and Financial Consideration (Curio coral)

As the market is almost entirely the United States, corals are paid for by sizes categories measured in inches. Following are examples of prices ($F) paid to the collectors for corals destined for exportation.

Table 6: Size(inches) Purchase Price Per Piece (Viala, 1988).

5-10	$ .15
10-20	$ .20
20 and over	$ .40

	Prior to 1992/	After 1992	1998
3-5			$ .06
5-7	$ .22	$ .12	$ .12
7-10	$ .25	$ .18	$ .18
10-15	$ .30	$ .30	$ .30
15-20	$ .35	$ .65	$ .65
20-25	$ .80	$1.50	$1.50
25-30	$ .80	$2.20	$2.00
30-35	$1.20	$3.00	$2.50
35-40	$1.20	$4.00	$3.00
40-45			$3.50

The price increases (30-330%) indicate a desire in the market for larger coral sizes. Prices for four coral types (Tubastrea micrantha, Turbinaria frondens, Merulina ampliata and Turbinaria sp.) were between 16-33% higher than the above reflecting a market preference.

With in this price scale, the financial benefit to the suppliers and employees has been estimated in excess of $1000 per week in Fiji. In the mid 1980's, the operation was halted due to disagreements between villages in the region, where by, the Department of Fijian Affairs closed down the business. The loss to the collectors by way of wages and the purchase of the product was estimated by the exporter to be $60,000-$80,000 per annum. This was to rise as the result of an increase in operations to $100,000 to the collectors.

In another enterprise, payment is made on the basis of a filled container which is $150 per person (5 collectors). An additional sum is paid for packing. The collecting time per container averages three days, though they are dispatched at the rate of 1 to 2 per week. Market requirement and the collecting conditions are responsible for the variability.

Other benefits include renovation of the community center, contribution to a village fund, vehicles used in the transport of supplies and in some cases the evacuation during medical emergencies.

14.4a Fisheries Questionnaire and Information

Below is an example of a questionnaire that was used to compliment the interviews. Following the questionnaire, are the composition of the samples from the villages sampled. The villages sampled are involved in *live rock* harvest.

Gender Age

1) What is the length of time that you have been fishing this reef?

2) What is the length of time that you have been fishing any reefs?

3) What percentage of your daily fare or income comes from fish caught on the reef?

4) What do you normally catch on the reef flat?

5) How much? What are the seasons? What is the range of amounts? Are there seasons? If so, what is the 'In season' and 'Out of season' the five most important species (i.e. Kuita, Kawa Kawa etc.)?

6) What do you normally catch from the reef edges?

7) How much? What are the seasons?

8) Has the amount of catch changed over the period of your life?

9) Has the amount of catch changed in the area where the coral is being extracted?

10) How and why has it changed?

11) Are you confident about your assessment of this change or lack of?

Location and date of the sample:

Malomalo Village -- Date of sample: 15/10/98.
Naidiri Village -- Date of sample:
Vatukarasa -- Date of sample:

14.4b Sample characteristics

Table 7a: Age sample

Age	Malomalo	Naidiri	Vatukarasa
0-9			
10-19			
20-29	3	1	
30-39	3		2
40-49	5	1	4
50-59	2	2	1
60-69	2	3	
70-79			1

Table 7b: Length of time you have been fishing this reef

Years	Malomalo	Naidiri	Vatukarasa
0-9	2		1
10-19	8	1	2
20-29	3	2	2
30-39	1		2
40-49	1	4	
50-59			1
60-69			

Table 7c: Length of time you have been fishing any reef

Years	Malomalo	Naidiri	Vatukarasa
0-9	1		
10-19	9	1	3
20-29	3	2	2
30-39	1		2
40-49	1	4	
50-59			1
60-69			

Table 7d: Percentage (%) of daily fare or income that comes from fish caught on the reef.

Percentage %	Malomalo	Naidiri	Vatukarasa	Percentage %	Malomalo	Naidiri	Vatukarasa
0	4			50-59	2	7	2
1-9	1			60-69	1		
10-19			1	70-79			
20-29	3		1	80-89	1		
30-39			2	90-99			
40-49	1		2	100	2		

14.3 Variation in the fringing coral reefs along the southern coast of Viti Levu.

Introduction

The line transect method was used to compare general characteristics of the reef flats used for *live rock* extraction and those where no harvest had taken place. What resulted from the study was an appreciation of the wide range of habitats that exist in the central reef flat region along the fringing reef.

Method

The central reef flat area was sampled using a transect line of 20 to 40 metres. This line was laid, perpendicular to the shore half way across the fringing reef. The benthos under the line was measured. The information is processed by the AIMS Reef Monitoring Data Entry System (ARMDES) for reef survey (English et al. 1997). The 20 metre transect lengths are linked, as required, to provide a 'reasonable sample' for the description of the habitat. The transect line is laid with regard to habitat features to be described. Before the line transects could be run, familiarisation of the benthic elements are required. This is accomplished by compiling a preliminary reference collection and by constant verification in the field concerning identifications. Abbreviations of the names of benthic items or attributes are used to provide consistency and facilitate data entry. Data is recorded on plastic sheets and retained as archival field data. Readings are taken along the tape where there is a change in the underlying benthic attribute. Attributes comprised species or generic presence, dead coral and uncolonised substrate. These are measured to the nearest centimetre. The categories generally considered are elements with in *Coral, Algae* and *Substrate*.

Results

Table 8: Comparison of benthic attributes on central reef flat areas along southern Viti Levu.

Village adjacent to reef sampled		**Substrate Characteristics %Coverage**					
		Hard coral			**Algae** (macroalgae)	**Abiotic** (sand; rock; etc.)	**Other**
		Total Coral	Acropora sp.	Non-Acropora sp.			
Malomalo	**1**	4	0	4.1	14	82	0
	2	4	.25	3.38	8	86	0
	3	3	0	2.75	11	86	0
Naidiri	**1**	2	.5	1.6	0	98	0
	2	2	0	1.5	0	98	0
	3	5	0	4.5	0	98	0
	4	10	5.6	4.2	3	88	1
	5	13	10	3	3	84	0
Navole	**1**	2	1	.75	46	52	0
	2	0	0	0	74	26	0
Komave	**1**	0	0	0	9	91	0
	2	0	0	0	27	73	0
Vatukarasa	**1**	0	0	0	34	66	0

	2	0	0	0	24	76	0
	3	1	0	1	39	60	0
	4	0	0	0	23	77	0
	5	3	0	3	45	48	0
	6	2	0	1.75	29	69	0
Sovi Bay	**1**	6	0	6.2	64	30	0
	2	15	0	14.8	11	74	0
	3	0	0	0	73	27	0
	4	3	0	2.75	78	19	0
	5	43	10.75	32	0	57	0
Malevu	**1**	41	8.4	32.5	0	59	0
Korotogo	**1**	6	.75	5.25	28	66	0

Discussion

Reefs varied substantially in there basic composition. By virtue of their extensive intertidal exposure, some areas were characterised by sand and rubble. Areas in the proximity of creek outfalls exhibited a preponderance of algae and a reef flat that had been filled in by the skeletal fragments of the corals killed by the periodic flooding. The deeper lagoon areas hosted good hard coral abundance. Given this range of fringing reef habitats, it is evident that there are some areas that would benefit from the extraction of live rock through the creation of a varied topography with the subsequent ponding of intertidal water. Equally, it is evident that other areas could be easily destroyed by the harvest of *live rock* such as in the deeper reef flat lagoons. Both Malevu and Sovi 5 represent this habitat type.

Two important observations became evident through the comparison. The wholesale dedication of the reef near Malomalo Vlg. has caused inundation of the hard coral community and initiated a proliferation of macro-algae particularly *Turbinaria ornatus* and *Sargassum spp.* By comparison with the Sovi Bay site, '*Best Practice'* would suggest the harvest be confined to the areas peripheral of the shallow lagoon. Protection of the patch reefs in the lagoon, would maintain the existing habitat that is important to the octopus (kuita) fishery.

Secondly, the adjacent sites near Komave and Navola villages are an examples of areas where the coastal influence of freshwater run-off has conditioned the nature of the coral reefs. One reef has been mined for *live rock* for four years and the other untouched. The nature of the reefs were very similar with no evidence of the harvesting having any particular influence. In both cases the coral cover was very low and there was a substantial presence of macro-algae.

Figure 27: Percentage of fauna, flora and substrate at the sites of *live rock* extraction and in adjacent areas.

14.0 Export Records: An Inaccurate Assessment of Coral Exports

These figures are the numbers of exports allowed through the Fisheries Division permit system but do not reflect the quantity of exports due to the practice of permitting for quantities in access of that which is sent. This inflation is on the order of 4-10 times the actual consignment. See section 6.1 Export statistic problems. This data is presented to help explain the range of values which has been attributed to Fiji.

Table 9: Production for 1996/1997 & Forecasts for 1998 to 2000* maximum permitted values only, not export quantities.

Years	1996	1997	1998	1999	2000
Live coral (pcs)	318,299	478,636	497,732	447,505	602,256
Live Base Rock (mt)	414	984	1,082	1,190	1,309
Live Giant Clams (pcs)	431	17,860	19,646	21,611	23,722
Unworked coral (pcs)	102,749	113,024	119,062	130,968	144,065
Worked coral (pcs)	0	0	2,000	2,200	2,420

*Fisheries Division Data

Table 10: Quarterly Production 1998* maximum permitted values only, not export quantities

Quarter	1st	2nd	3rd	Totals at 3rd Qrt.
Live coral (pcs)	105,942	94,751	152,466	353,159
Live Base Rock (mt)	424.40	361.23	313	1,098.63
Live giant clams (pcs)	9,466	8,377	11,731	29,574
Unworked coral (pcs)	27,310	25,912	20,820	74,042
Worked coral (pcs)	0	0	2449	2,449

*Fisheries Division Data

Table 11: Monthly export rates* maximum permitted values only, not export quantities

Months	August	September	October	November	Total
Live coral (pcs) WSI	14,890	34,440	60,760	42,515	152,605
Live Base Rock (kgs) O2L, SSE, WSI & WL	99,500	121,500	158,150	130,250	509,400
Live giant clams (pcs) WSI	2,250	4,140	11,749	11,915	30,054

*recorded by the Lautoka office. These figures represent domestic export plus the re-export of live material from Tonga and the Solomon Islands. The live rock export represents the combined export. Waterlife (Fiji) live rock has not been included. Ocean 2000 Ltd (O2L), South Seas Export (SSE), Walt Smith International (WSI).