Status Report:

Collection of Coral and other benthic reef organisms for the marine aquarium and curio trade in fiji

Prepared by: Edward R. Lovell

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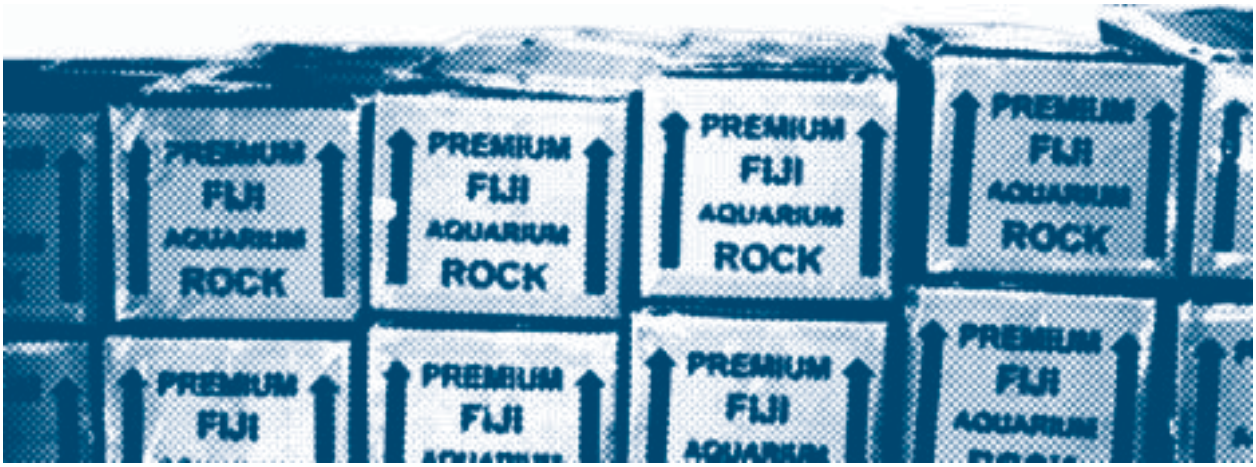


EXECUTIVE SUMMARY

1) The ornamental or curio coral trade has previously been the principal coral product exported from Fiji. With advances in technology allowing “mini-coral reef aquarium” hobby, there has been a growing market for live coral, both hard and soft, and a variety of other reef creatures notably clams and anemones. Live rock is an important part of the aquarium and has proved to be a growing market.

2) Of the Seven companies are operating in Fiji, five export live coral, fish and live rock and two are concerned solely with curio coral export. The export of coral reef fishes and curio coral from Fiji has occurred for the last 16 years. The Live Rock industry has been operating for 7 years and live coral exports for 5 years.

3) Concern exists as to the environmental effects of removing organisms and coral rock from the reefs, particularly, with regard to the compromising of the subsistence and artisanal fisheries. This is a vexing question, as the longer-term data required providing certainty of sustainability is lacking. No programs are in place to obtain such information due largely to the lack of funding for the Fisheries Division involvement or by marine scientists.

4) 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. Collection in the worst case may result in the depletion of that species in the area of collection and localized reef degradation. The ability to recolonize 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.

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

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

7) Live rock collection can be engaged with minimal environmental impact on the local fishery. In some cases, however, inappropriate practices have been highly destructive to the existing reef flat and lagoon.

8) Curio coral collection, more than other types of collection, involves the removal of species from shallow reef tops and collection of a wide range of size categories. The large area for collection allows for an abundant resource. The detailed effects of the extraction 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. Apart from the proliferation and replacement by non-commercial species, unsuitable specimens of the commercial ones are generally abundant.

9) The Fiji Government Fisheries Division publication: Lovell E.R. and Tumuri M.1999. *Provisional Environmental Impact Assessment for the Extraction of Coral Reef Products for the Marine Aquarium and Curio Trade in Fiji* details requirements to assess sustainability and provides recommendations for management.

10) The export of aquarium products and curio coral has been increasing with prospects for a continued expanding market. Though opportunity exists in the market place, information on the impacts on the coral reef ecosystem are lacking causing concern.

11) Record keeping by the Fisheries Division needs to be reviewed. The uses of inflated export numbers are incorrectly used as actual exports. The trans-shipped products through Fiji need to be accounted for as it is often confused with the domestic exports.

12) There is a lack of awareness as to what is involved in coral harvesting industry. Interviews with the resource custodians indicated a divided opinion on the effect of live rock and curio coral removal on their fishing areas.

13) Management responsibilities between the resource custodians and the Fisheries Division with respect to curio and aquarium products collection are unclear.

14) The Fisheries Act (1992) requires reviewing as to its relevance to this industry, and licensing needs to be brought into line with the Act. Export permits should be brought under the jurisdiction of the Fisheries Division.

1.0 INTRODUCTION

Commercial collection of the living material from coral reefs for export has caused concern with regard to its environmental impacts and its sustainability. The demand for aquarium products and curio coral is growing. 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 rapid emergence of the fishery has out paced management, traditional or otherwise, that is based on biological data. Proponents and opponents have used general ecological relationships categorically, which has more often confused the issue. This issue is sensitive and discussion of the collection is often based largely on an appreciation for coral reef life, irrespective of its potential benefits as a fishery.

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

The objective of this report is to provide an overview that 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 at policy-makers, resource owners and users, and those interested in understanding the various points of view concerning this emerging fishery. The history and trends in the different activities are assessed.

A summary of the current debate and contentious issues concerning coral harvesting activities are presented. These include an 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 that it is likely to impact on. Recommendation and guidelines are suggested as to *best practice*. The views of the resource owners are obtained through interview with an assessment of the current practices and mechanisms of the harvesting of coral.

The market for both dried coral colonies and live aquarium material is large. Bleached or coloured coral has always provided a fascination for nature's architectural forms and stimulating interest in corals. Within the last decade this fascination 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.

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 provides the opportunity for additional income for coastal inhabitants. 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.

2.0 TYPES OF COLLECTION: THE COMPANIES OPERATING

2.1 Definitions

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 materials 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 (a) curio or ornamental coral which are coral skeletons; (b) live aquarium products; (c) live rock which is portions of reef rock covered with attached organisms, particularly, coralline algae.

Corals are also used in 6 other minor ways. These are (a) live sand for aquarium landscape and filtering (b) Aquaculture of corals and other marine organisms: Grown in special facilities generally from fragments. This approach is in its infancy in Fiji. (c) It is used industrially for the production of cement, mortar and agricultural lime. Corals are also taken infrequently for (d) medical purposes and for (e) scientific research, but these represent small amounts. (f) The removal of massive corals for sewerage soakage pits is discussed.

Depending on the type of collection, the practices differ substantially in their operation and impact. Extraction for aquarium products involves the collection of a large number of different organisms and reef rock. Generally, these are small colonies. Every effort is made to keep these colonies alive which involves careful collection, proximity to international air services, substantial infrastructure to maintain the living animals for the market place. The curio trade by contrast removes much larger colonies. The product is dried, boxed and shipped by container overseas. Live Rock is mostly reef rock though it forms the habitat for infauna and cryptic organisms if extracted according to “best practice” methods. In the worst case, its extraction may alter the habitat for coral and fishes. In many cases, the life histories of the organisms 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 its benefits and impacts.

2.2 Types of coral reef plants and animals collected

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 collected by the aquarium trade. The aquarium trade may take a variety of taxa, plants and animals, in order to mimic a coral reef. Appendix 14.1 details the taxonomy of the organisms liable for collection. While some are unsuitable for an aquarium existence due to their behavior or feeding requirements, others such as *Corallimorpharians* may be colorful and easily kept in captivity.

2.3 The Exporters

Of the seven companies operating in Fiji, five are engaged in the collection of aquarium products: Ocean 2000, South Seas Export, Walt Smith International, Waterlife Fiji and Aquarium Fish (Fiji) Limited. The remaining two companies deal in the collection of dried corals or the like: Seaking Trading and Acropora International (Table 1). Aerial photographs and the *i qoliqoli* boundaries are shown in Lovell and Tumuri, 1999. The reef area and types are shown in the aerial photographs of the collecting areas.

Table 1. Details of Companies Operating in Fiji

Company	Products		Staff			Facility	Capacity	Location	Capital Invest. (FJDS)	Year oper.
			Perm.	Casual	Collector					
Aquarium Fish Fiji	Aquarium	Fish Live Coral	20	0	22	UV sterilization, protein skimmers, mechanical filtration, carbon filtration, and biological filtration with drip systems.	12,000l.: fish, coral	Pacific Harbour	300,000	16
Ocean 2000	Aquarium	Fish Live coral Live Rock Assorted benthos	26	7	106	Fish system: protein skimmer; sand bed filter; UV sterilizer; air conditioner. Coral system: No refrigeration or UV sterilization Buried reservoir and shade over troughs for natural cooling.	27000l: coral 18000l: fish	Nausori (aquarium products); Nadi (live rock)	515,345	7
Tropical Fiji Fish/South Seas Export	Aquarium	Fish Live Rock	15	0	6	Regularly replenished seawater reservoir, UV sterilization, a protein skimmer and refrigeration.		Wailada, Lami (Fish). Komave, Coral Coast: (live rock).	1,500,000	2
Walt Smith Internatn'l		Fish Live coral Live Rock Assorted benthos		63	86; 383	Five separate holding systems: (a) live rock; (b), hard and soft coral: (c) *Tridacna* clams, anemones and starfish. (d) Fish l. (e) An isolated system is devoted to soft corals. The system has a large array of metal halide lamps; a protein skimmer; refrigeration; anti-bacterial control through UV light; ozone injection and chemical additives (fish).	(b,c) 27,240l (c) 6,800l (d) 31,780 l (e) 31,780 l (e) 6,800l 50% weekly water change for all.	Lautoka	3,500,000	8
Waterlife Fiji	Aquarium	Fish Live Rock	3	0	15	Reservoir, protein skimmer.	4500 l. coral 8000l. live rock 12,000l fish	Wailada, Lami	500,000	10
Acropora Internatn'l.	Curio		4	0	63	Raw dried coral boxed in crates and shipped by container.	-	Nasinu	1,600,000	7
Seaking Trading	Curio		7	10	24	Export as above. Now unoperational due to dispute. Value- added approach: bleached and packaged for	-	Wailada, Lami/	100,000	15

Figure 1: Location of aquarium, curio coral and live rock extraction sites

Companies and collection type:

1. **Seaking Trading Co.: Curio**
2. **Acropora Int'l.: Curio**
3. **Ocean 2000: Aquarium**
4. **Waterlife, Fiji: Aquarium and live rock**
5. **Aquarium Fish, Fiji: Aquarium**
6. **Tropical Fish, Fiji: Live rock**
7. **Walt Smith Int'l: Live rock**
8. **Ocean 2000: Live rock**
9. **Walt Smith Int'l: Aquarium**

2.4 Collection of Live Organisms (Fig 2a-h)

This is the general collection of 'wild-caught' reef organisms that are amenable to aquarium life and includes such sessil forms as hard and soft coral, anemones, zoanthids, and mobile invertebrates such as gastropods, crustaceans and starfish. This activity involves the removal of live reef organisms and subsequently the holding and packaging for trans-shipment to foreign destinations. The collection in all cases is contracted out to villages with an *i qoliqoli* (customary reef rights area) from which divers collect specified reef animals. No underwater breathing apparatus is used (except with Fisheries Division exemption) and collection is from relatively shallow reef areas less than 6m depth. Permission has been granted for collection on the west side of Viti Levu and is being considered for coral collection in deeper waters. The divers are trained in the removal and care of the organisms during transit back to the holding facility. Corals and other immobile invertebrates are removed with an iron bar, chisel or screwdriver, which preferably includes a small portion of the reef to which the organism is attached. Most of the hard and soft corals are collected as whole colonies, though some are fragmented. Both branching and massive species of hard coral are collected. In the case of the corals, the size of the material is limited (<15 cm diameter) by the nature of the market demands. In the case of 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 a sealed a plastic bag of water with an air space, or covering it with plastic wrap to prevent injury. These are then placed in a holding bin until unloading at the holding facility.

Figure 2 (a-h): Live Coral Collection: Hard and Soft

Live coral collectors prepare for the day's work at Vatani Village.

A diver removes hard coral from its reef attachment using an iron rod.

Soft coral *Xenia sp. is* removed from their boulder substrate.

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

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

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

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

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

The holding facilities among the aquarium 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 (3.2.). This includes hard and soft coral, *Tridacna* clams, anemones and starfish. The system devoted to soft corals, 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 exclusively for soft coral and has a capacity of 31,780 l. There is also a system of equivalent volume used for tropical fish. Each system has 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's water temperatures at sea temperatures and the water is sterilized by ultra-violet light and ozone injection. The tropical fish system has chemical additives, which provide additional anti-bacterial protection.

With this level of technological support, mortality is minimal 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 has good survivorship. 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 airfreight. Generally, this is to the United States but worldwide interest in aquarium products has opened up markets elsewhere. Occasionally a shipment is not loaded on the flight, which requires the supplier to unpack all of the shipment and return it to the holding system to await the next flight.

Ocean 2000 Ltd. operates in the Vanua Kabuna or Bau Waters. The owners are Tai Hancock and Nemani Turagaiviu. The collectors come from Mr. Turagaivu village of Vatani on Kaba I. The collecting areas are from Vanatu Passage in the south to Moturiki Passage in the north. There are 106 collectors that operate on a rotational basis using nine boats.

There has been some contention in the issuance of permits for commercial extraction in this area. As chief, she has the prerogative to issue a permit without the consent of the *i qoliqoli* owners, their consent being implicit in the traditional basis of her position. The exclusion of other resource users in this decision, however, has resulted in a great deal of suspicion and concern over the impact of coral extraction on the resource base and consequently on other areas of resource use. The Mua-I-Kaba co-operative, in particular, is concerned at the impact of coral harvesting on the reef base, which supports their commercial fishery. No conditions have been placed on the level of coral extraction permitted with in Kubuna and other users are concerned at the evidently increasing rate of harvesting (Van der Meeren, 1996).

Walt Smith International operates north of Lautoka in the vanuas of Vuda; Waya, Naviti and Marou; Naviti and Marou; Marou and Naviti 2. This is a large area of 1600km^2. The collecting is mainly conducted in the reef systems between the islands of Naviti and Waya and the main land. The collectors come from Naviti I.

The other marine fauna exporters are Waterlife, Fiji and Tropical Fiji Fish who export fish and live rock. Aquarium Fish, Fiji export mainly fish but have recently engaged in coral export which has been curtailed with the coral bleaching event in the April of 2000.

2.5 Live rock extraction (Figs 2-4a-h)

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 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, and any fauna or flora residing 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 and 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.

All of the companies involved in the live aquarium 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 *i 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, and is purchased by the kilogram from the collectors minus any material that is rejected as unsuitable. The rejection rate is relatively small as the feed back to the village collectors is immediate.

Live rock is collected from the edges of the reef flat patch reefs within the shallow lagoon 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 15-35cm. 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 is occurs at Koroniuniu Reef adjacent to Malomalo Village (Fig 1a-h) and Vatumalawa Reef adjacent to Komave Village (Fig. 5a-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 *i 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 to 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.

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 that 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 that may be associated with the live rock, it is important that any mortality associated with the rock occur outside of the tank. Failure 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 and are trained. Those reliant on subsistent fishing utilize both the collection areas, as well as, other parts of the *i qoliqoli* or adjacent ones.

The controversy over whether to cure the rock or not, conditions the way the respective companies conduct 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 in the shallow water of the reef shortly after collection returns some of the marine organisms

and unwanted biomass 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 given sessile or attached organisms are unable to re-attach. 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 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.

Aquarium Fish Fiji is investigating an additional source of live rock in the Deuba-Beqa area. Unlike the reef flat source, this material is located at a depth of approximately 10m, and 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 also makes it unsuitable as fish habitat. Its removal would require underwater breathing apparatus, and collection of this resource be subject to an environmental impact assessment.

Four examples of live rock collection are provided in sections 2.2.1 – 2.2.4.

2.5.1 Malomalo Village (Koroniuniu Reef)

A portion of the *i qoliqoli* is totally devoted to the extraction of live rock along the reef flat, from shore to reef crest to provide a weekly quota of live rock (Fig. 3a-h). The view adopted by the village collectors 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.

Ocean 2000 extracts live rock from the *i qoliqoli* of Malomalo village. This operation has been in existence for 4 years. Ratu Sola Maiyale is the chief of the village and 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 *i qoliqoli*. The villagers of Malomalo have the opportunity to utilize the neighboring *i 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. He is assisted by the *Turaga ni Koro* who manages the field operation while 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. Other groups load the rock onto the *bilibili* and transport it ashore, provide an initial cleaning and support ashore such as arranging tea breaks and lunch. The truck and driver who transport the material to Nadi are from Ocean 2000 Ltd.

The general opinion of those engaged in the collection is that the industry was of undeniable benefit, particularly so during the period of drought when there was no sugar cane to harvest. 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 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 because there are strong opinions in the village that this activity is very harmful to the subsistence 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 of 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. corn beef or lamb flaps). Concern has been expressed that the benefits offered by the reef will be denied to future generations, due to this destructive activity.

2.5.2 Komave Village (Vatumalawa Reef)

Tropical Fish, Fiji (formerly South Seas Export Ltd.) has mined live rock for three years (Fig. 5a-c). As with Malomalo, only a portion of the *i 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-alga 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, resulting in low diversity and abundant macro-algae. However, Nalumu (Navola) Reef and is located at the southern end of the Vatumalawa Reef and has never been mined for live rock. It experiences the same physical environmental regime, as does the area of collecting activity. Interestingly, 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, and appears to be the result of the reef flat being largely conditioned by its proximity to several freshwater outflows from Komave Creek, Navola Creek and the Namatakula River. Field observations after the first rainfall in six months showed that coral growth was killed by the freshwater run-off. The resulting skeletal material would then be deposited on the reef flat, which was characterized by loosely packed coral skeletons of the same genus. This is largely branching material of the fast growing genus *Acropora.*

2.5.3 Vatukarasa Village

Walt Smith International has been extracting live rock here for four years. It is collected 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. There are two rivers, the Sovi and the Tamanua rivers, which empty into bays on either side of the reef. These creating 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. 4a).

The other site (Fig. 4b-h) has an inner lagoon that is characterized by a good luxuriance of coral. It is surrounded by an algal crest or flat which forms the western margin of Sovi Bay and the seaward edge of 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.

2.5.4 Suva Harbour

Waterlife, Fiji extracts live rock from this area with the material coming from two sources. Rocks with the desired coralline alga on their surfaces lie unattached on the subtidal reef flats and characterize one area, and the second source is from the dead base of the live coral from the extensive areas of coral growth adjacent to 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 be progressively destructive on a uniquely luxuriant stand of *Porites cylindrica.* To obtain the algal covered material, the living coral would have to be removed.

Figure 3(a-h): Live rock collecting operation adjacent to Malomalo Village

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.

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

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

Colonization by the macro-algae *Turbinaria ornatus* and *Sargassum cristafolium*. The algae are heavily fouled by epiphytic growth.

Transport of the reef rock ashore.

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

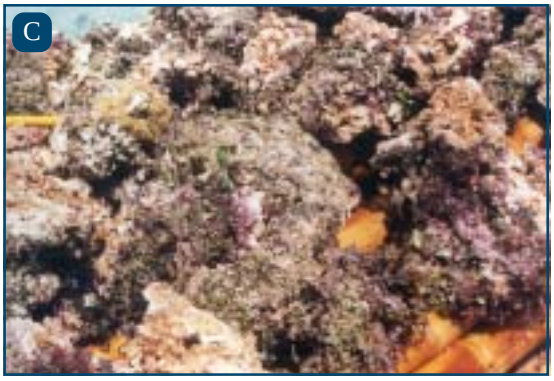
Loading and transport of the rock to the Ocean 2000 holding facility in Nadi.

Appearance of a destroyed reef knoll subjected to rock removal.

Figure 4(a-h): Live rock collecting operation adjacent Vatukarasa Village

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

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



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

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

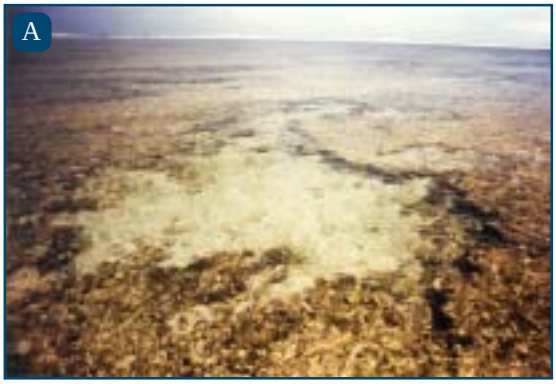
Collectors ferry the material ashore via *bilibili* raft.

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

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

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

Figure 5(a-g): Live rock collection – Komave Village for South Seas Export Ltd. (a-c)



The reef is characterized by shallow depressions within a rubble-filled surface that is exposed intertidally.

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

Komave villager cleans the rock in the shallow nearshore channel.

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.

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

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

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

2.6 The Curio Coral Trade

This involves the removal of whole hard coral colonies that are dried before shipment. They are collected for the purpose of selling their cleaned skeletons as decorative items. Described as decorative, ornamental or curio coral, the product is generally hard coral (Order *Scleractinia*) or related organisms with a hard skeleton. It is collected live, usually as a whole colony, and sold in a consignment, which is collected to order. Corals are taken from relatively shallow water (intertidal to 3m). Waste is minimized 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. 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.

They are sorted into groups based on colonial form and wrapped securely with newspaper. The corals are then boxed in heavy wooden crates, 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 souvenir, its usefulness depends on the care taken of the specimen. 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.

Those specimens preferred because of their attractive 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 (Order: 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 Coenothecalia) 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 precious corals present in Fijian waters such as those collected at depth off Hawaii and used for jewelry.

Figure 6(a-h): Curio coral harvest adjacent to Viti Levu Bay by Seaking Trading Co. (Fig 6a-h; 7b-c, g).

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

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.

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

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

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

Cleaning and bleaching of coral specimens prior to packaging.

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

Coral specimens ready for dispatch to the United States.

Figure 7(a-h): Coral collected for curio, medical and septic systems (Photos of Acropora Intl. Ltd. Fig. 7a,d-f).

Coral is being dried and packaged for container shipment by village communities.

Branching *Acropora nobilis* drying in the village.

Solitary corals of the genera *Fungia (left)* and *Herpetolitha* (right) ready for packaging.

Collection of tabulate corals *Acropora hyacinthus* by Acropora International in Kabuna waters.

Removal of coral from its reef substrate using an iron rod.

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

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

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.

2.7 Other Coral-Derived Products

2.7.1 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, diatoms, calcareous algae and coralline algal accretions. It is considered *live* due to the presence of interstitial fauna such as worms and small crustacea. Also represented in the sand by their symmetrical skeletal shells, are the foraminifera, which are common subtidal fauna. The presence of the red skeletons of the pipe organ coral makes for an attractive addition to the white calcareous material. It is preferred to siliceous sand of terrestrial origin. The sand aids in water filtration and as a substrate for micro-organisms.

The amount of sand that is available within a reef system is large. Erosional forces and the natural attrition of the skeletal components of the reef fauna continuously produce it. The removal of large quantities of sand such as in dredging or beach restoration can create further erosion or 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 a beach of particularly attractive sand is taken from a resort location or 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.

2.7.2 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 plaster that is applied to the bottoms of boats as an antifouling barrier. Subfossil corals are mined in Moreton Bay, Australia as a carbonate source for the production of cement (Qld. Cement and Lime Co., 1964). Fiji Industries Ltd. mines many thousand tons per year of carbonate sand from the lee or back reef side of Nucobuco Reef along the southeastern margin of Laucala Bay. This is used for both the production of cement and agricultural lime. This relic material has been deposited during the period of the Holocene high sea level (3-5000 yrs. BP.). An environmental impact assessment for this operation has been carried out (Penn, 1982, 1983).

2.7.3 Coral for Septic system drains (Fig. 7h)

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 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 Road. A pile of coral sells for FJD$40. An average sized coral is 60 years old. Far from sustainable, this practice is equivalent to the mining of the living resource that 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 also incorrect to think that the porous nature of the skeleton is effective, as once saturated with water it is relatively impermeable. Elsewhere course gravel is used. This material is used because it was available where suitable alternatives were harder to obtain, and there is a misconception that corals are most suitable.

Curiously, this coral falls under the jurisdiction of the Lands Department who issues a mining lease under the assumption that the material is dead coral. This is not the case and given living material is being removed responsibility for the management should fall to the Fisheries Division. The present arrangement is based on recognition that Suvavou has a right to utilize their *i qoliqoli* resource. As it is considered largely mineral, the Lands Department officiates the permit though no environmental impact assessment has been carried out. It is apparent that the *i qoliqoli* has become degraded by the development of Suva and the port facilities. 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 size of the colonies indicates an age class (40-80 years) which should be considered unsustainable as the resource is being utilized faster than it can be restored through recruitment. The broader consequences of habitat removal and fisheries impact of this practice are unclear. 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.

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

2.7.4 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 that 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, as it is not recognized as being foreign by the human immune system.

The corals in demand are genera *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 as they are of inferior quality. Seaking Trading Co. periodically supplies a California pharmaceutical firm with whole colonies. The global trade in this coral peaked in 1992 at 26 tonnes, but declined to extremely low levels since (Green and Shirley, 1999).

2.7.5 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.

3.0 HISTORY AND CURRENT INTERNATIONAL TRENDS

The world market for ornamental corals increased rapidly in the 1970s and 1980s but 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 United States is the main consumer, accounting for 70%-90% of the trade. 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 United States imported 480 tonnes in 1988 from Indonesia (Wood and Wells, 1988; Wells and Wood, 1989).

According to 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 United States accounted for 56% as compared to 15% for the European Union. Asian exports were an order of magnitude more than their Pacific counter parts. Recently, Fiji (from 1994) and the Solomon Islands (from 1993) have become prominent exporters. Currently, the top ten exporting nations are Indonesia (41%), China (24%), Philippines (18%), Fiji (4%), Taiwan (2%), Solomon Islands, Vietnam, Marshall Island, Tonga and Mozambique (all at 1%). The 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 Shirley, 1999).

3.1 The United States Aquarium Trade

In 1986, TRAFFIC (U.S.A.), responsible for tracking the international trade in endangered plants and animals, estimated that there were 10 million marine aquarium hobbyists. The value of the global ornamental trade (marine and freshwater) had risen to US$ 7.2 billion. About 10 % of the estimated 350 million aquarium fish involved in the trade (i.e. 35 million fish) are currently thought to be marine species. 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 invertebrates, from $1000 to tens of thousands of dollars New aquarium technology and better understanding of the biology and ecology of aquarium inhabitants and of the compatibility and husbandry of marine organisms are key factors contributing to the expansion of the marine aquarium hobby and trade. (Derr, 1992; Holthus 2000). Sales of marine aquariums 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% (560,000) of these being tropical. It is estimated that 6 million pieces of live coral, 18 million pieces of soft coral and 50,000 tons 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 their own homes.

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, United States illegally imported about 600 tonnes from the Philippines, violating both Philippine law and the Lacey Act of the United States that 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 United States and Japan. Between 1985 and 1995, 43% of exports were live corals (e.g. *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 United States 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 utilized. 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 United States 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 United States coral imports (Mulliken and Nash, 1993).

3.2 Fiji

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 whereby they are seeking, through prohibition and limitation, to confine the harvest to sustainable levels.

Lack of valid export statistics (see section 6.0) allows only an estimate of quantity of material actually being exported. The reality is that these figures represent maximum permitted exports only and not the actual exports shipped. From a recent audit of Walt Smith International exports, the figure is approximately 9% of the recorded value. The bogus Fiji export statistics recorded over 12,000 pieces of live coral in 1991 with the figure approaching 500,000 in the last two years (478,636 in 1997 and 4,976,732 in 1998). Projected exports for the year 2,000 are in excess of 600,000 pieces. The actual figure over the last two years is probably more like 45,000 pieces.

Table 2 Live Coral and Curio Trade in Fiji - Summary of the financial details

Total No. Company	Expenditure/Sales		Staff			Wages	Payment to collectors
	Product Sales	Freight (FJD$)	Perm.	Casual	Collect		
Total 7	$9,783,216	$3,260,569	125	17	369	$740,491	$1,123,207
			Total Direct employ't 495				

Vanua payment	Utilities: Electricity/Telecom	Local purchases/imports	Total Revenue	Total capital Investment	Years operation
$126,398	$124,199 electricity $187,432 phone	$1,892,523 imports $190,000	$9,783,216	$8,015,345	1-15 years

3.3 Factors Conducive to the Coral Trade

Several factors make Fiji ideal for the export of live coral: (1) The first is the dual tenure system whereby the coastal villages manage the fisheries resources of their customary reef areas. (2) Adequate infrastructure allows transport and holding of the live product. (3) The airline services are able to deliver the live specimens in a timely manner (<16hrs.). (4)Good shipping services for the transport of container-packed curio coral.

The export of coral products from Fiji is 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 of those existing and new ones are being attracted. Many of the coastal villages are eager for the income derived from the new resource. A limiting factor is the availability of cargo space on the airlines.

3.4 Pacific Islands and Australia

New Caledonia, through the export of brain coral (Family: 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 8 tonnes of coral for medical purposes to the United States in 1989 but the export is now prohibited. Similarly, Vanuatu exported coral in 1991 and 1992. A small amount of *Heliopora* was exported from Kiribati to the United States through the Fijian company Seaking Trading Co. The Marshall Islands exported 18 tonnes in 1990 and the Solomon Islands, 6 tonnes to the United States in 1991. Tonga attempted to export coral for medical purposes but the government banned all harvest in late 1993. The Federated States of Micronesia has 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 tonnes of coral was being harvested annually (Oliver 1985; Oliver and McGinnity, 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 (GBRMPA). In 1983, there were 12 active collectors of which two accounted for 60% of the market. They 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 GBRMPA. Due to its distance from the mainland, the Great Barrier Reef is, in general terms, one of the least exploited reefs in the Indo-Pacific region.

Where there are coral reefs, there is often a demand for coral souvenirs for the tourist industry. With prohibition of local curio harvest in Fiji, 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 is supplied by SE Asia, as well as Fiji.

Depending on the type of extraction, coral reefs vary as to the amount and type of living materi

4.0 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 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, the scale of operations 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.

Coral reefs in Fiji and the Pacific Islands are important resource fisheries for a subsistence fishery that 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 prospect 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 benefits 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 that may yield substantial benefits to village life. Sharing these concerns are the people who have and

continue to depend upon these reefs for a good portion of their livelihood and have for generations. The *i 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.

4.1 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 not to engage in enterprises that be disruptive 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 of 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 resilience of natural abundance and recruitment to accommodate collection.

Concerns over the activities of these industries are based on the negative impacts that they may have on the coral reef systems. 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 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.

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 leads to a reduction in both 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 observations 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 present. Herbivorous fish thrive in the areas of fleshy algal growth which has also been responsible for the death of coral (Lovell, 1997).

The sustainability of collection based on the variability in growth rate is often questioned. 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 colonization 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 and Bour 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) which are not taken serve as a source of recruitment as do the uncollected reefs upcurrent from the resource. Collection of some colonies such as the tabulate *Acropora* may be more quickly replaced by coral and other organisms that

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 there is relatively quick recolonisation (< 3 yrs.) in an hospitable environment 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.

Coral reef management itself is a cause for concern. In Fiji, the dual tenure system combines the responsibilities of the central Government with those of the traditional custodians of the customary reef areas to work in a partnership to manage the inshore fishery. The precise legal nature of this relationship is unclear. A third partner in management is the exporter whose style of business and product requirements affect the fishery. This gives rise to problems when the management of the resource or the industry 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 that can be relied upon 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 have 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, continue 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 or not these extractive practices may be 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 *i qoliqoli* resources, particularly when it results in extensive alteration of the reef environment. It may be that 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.

Common to all types of collection are 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 minimize it. Waste is loss of profits. Unfortunately, the selection process is often been perceived as one of waste, conducted by collectors who take material that 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 of the coral makes them prone to breakage and only intact or uninjured corals are acceptable in the foreign markets. Careless collecting can also damage other non-target species and organisms peripheral to the coral being removed can be adversely affected.
Commercially, it is in the interest of the collector to ensure 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. The most efficient way to collect coral is to lift it after detachment and swim with it to the boat or stockpile it in a sandy patch for immediate collection.

4.1.1 Live coral and other bottom dwellers

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 minimized. 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 localised collecting area. For many species it seems unlikely, as the size sought is small, leaving an abundance of the larger organisms. Naviti Island in the Yasawa island group is an example where the *i qoliqoli* consist of large areas of remote reef. Here the conflicts of tourism and subsistence fishing are not an issue.

4.1.2 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. 4). The material being removed is a combination of algal origin and, most probably, relic reef material which was deposited during an earlier period of hundreds to thousands 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, while 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 vital in assessing the potential for erosional events that 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 subject to collection. In the Komave situation, the reef flat has little relief without a prominent lagoon. Its proximity to periodic river outflow 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 most probably increasing marine biodiversity for the area.

By contrast, in the Malomalo situation, the inner lagoon area has been fully utilized 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 *i 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.

4.1.3 Curio Specimens

Inspection of reef areas subjected to short term (1-2 yrs.) and four years of coral collection have proved difficult to detect any change that 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 assess areas with an unknown collection history. This coupled with the biological variability normally encountered on coral reefs, results in discerning the effects of collection being difficult to assess.

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

5.0 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 the Convention on International Trade in Endangered Species (CITES) all hard coral species plus *Tubipora musica* and *Heliopora coerulea* must be itemized on the export form. Additionally for the United States importation, a CITES form must be completed for non-CITES organisms which are attached to a reef 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.

2. Live giant clams — Small clams (generally <12cm) of the genus *Tridacna* are collected both from the wild and obtained from hatchery stock. Ocean 2000 and Walt Smith International are exporters of largely wild caught stock. Other reef plants and animals are collected but the only statistics available refer to clams.

3. Live Base Rock — This is the live rock material that represents algal covered reef rock.

4. Unworked coral is the hard coral exported by the curio trade.

5. Worked coral – This type of product are coral items in which value is added. Acropora International has produced limited coral products, which are fashioned through lathe work (e.g. lamp bases, table ornaments). All of Seaking Trading Co. export is in this category. Their products are bleached or coloured coral, clear wrapped with pricing code attached.

5.1 Export statistic problems

Unfortunately, the value of the statistics has proved unusable to assess the volume being extracted from Fiji's reefs for two reasons. The first is the Fisheries Division practice of including aquarium products that originate 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 International is the only firm currently trans-shipping Aquarium products through Fiji from other South Pacific countries. 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 United States exported to 19 different nations, coral products that originated from 15 other countries (Green and Shirley, 1999).

Secondly and 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 for any of the consignment species might result in the confiscation of the shipment. To guard against this, a large number of a particular item are given permits. This is routinely done as a template with the same large number covering many of the categories. Importing countries such as the United States do not 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, and minimizes delays in the permit processing or the prospect of not permitting for an adequate number of

specimens. The exporters, generally, submit a summary document that details their exact exports but this has not been used in the rectifying the fisheries export data. The permit numbers are as much as 10 times the actual exported quantity.

An additional problem is the use of two databases 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 leading to much confusion. 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 incorrect, confusing and severely diminishes comparative statistics. This is particularly the case for countries that 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 utilize the nature of the business and the impacts of their activities.

Finally, much of the data is taken in units of pieces and weights, 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.

5.2 Live coral: hard and soft

There is limited data available on the longer-term exportation of live coral, both hard and soft. This is due to reasons listed in the previous section. A approximation of the error factor in the existing Fisheries Division export quantities may be inferred by assessing the relative disparity between the correct export records from the largest exporter of live material. Over 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 were 22,996 pieces. Though the permitted and recorded quantity was 50,450 pieces, a figure 46% higher than that actually exported. Once again these represent a composite export from varied locations.

CITES permits are not required for soft coral or any of the other reef animals including fish.

5.3 Giant Clams: *Tridacna spp.*

One of the aquarium products that have 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 that reputes the large clams to be able to capture and drown an unsuspecting diver. Most of these bivalves 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 (1992). Both Ocean 2000 and Walt Smith International export giant clams. Wild stock is preferred because of the brighter and more varied colour (Fig. 2g). In Fiji, the Fisheries Division operates a clam hatchery on Makogai Island, Lomaiviti with the potential for commercially taking advantage of this market. Unfortunately, the Fisheries Division has yet to be able to supply stock from this source in viable condition.

As with the export of the live organisms, the export of clams represents product from various origins and a permitting system that 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 that allowed for 53,430 clams and was recorded as the quantity exported. Most of the clams originate from outside Fiji.

5.4 Live Rock or Coral Base Rock

Live rock is exported as small, irregular boulder shaped reef rock measuring in the order of 15cm to 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 291,837kg of live rock within a permitting quota of 606,000kg. 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 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. What was previously a lucrative US-based aquaculture industry for live rock has now proved uneconomical due to the availability of the wild-collected rock.

5.5 Unworked or curio coral

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 United States 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 3 **Number of pieces of curio coral exported between 1985-1989 and by weight in metric tons during 1990-1992 and the value (FJD/tonne).** 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

For Acropora International. the annual export for 1996 was 102,749 pieces and for 1997, 113,024 pieces, which represents a 10% increase. The market is clearly growing. For all curio products, these figures represent material collected in Fiji only.

5.6 Worked or Value-added Curio Coral

This is curio coral that is in some way processed for entry into the retail market. At this stage the export level is low. Seaking Trading Co. is the only company preparing retail products. They are holding a large quantity of unworked material. Initial problems with the processing end of the operation have limited product flow.

6.0 SURVEY OF RESOURCE CUSTODIANS' OPINIONS

To determine if there was an apparent change in the *i 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 in the curio trade. Discussions were held during the introduction *sevusevu* ceremony and interviews with those employed in the live rock and coral collection. Some of the interviews 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 effect of the reef extraction fishery on the fishery will require a monitoring program that will provide data on the diversity and abundance of fish in the area of extraction in comparison with similar unaffected areas.

6.1 Village 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 13.3a. Answers to the questions are contained in Appendix 13.3b 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 coral products were removed. The interviews were held October 15, 1998 for Malomalo Village, October 16, 1998 for Naidiri Village and October 23, 1998 for Vatukarasa Village.

Has the amount of fish 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 there 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, fewer respondents detected change. It was attributed to an increase in fishing activities over time, which now requires a greater effort to obtain the 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 the catch per unit effort had decreased and half thought otherwise. 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 abundant regrowth of macro-algae which attracts the fish. The increase is mostly algal feeding finfish. An increase in the abundance of octopus was indicated.

29% noted a decrease in finfish caught with one comment indicating a dramatic decrease. The amount of octopus had also decreased. 37% felt 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 to Naidiri. The coral extraction has provided much more money than that previously received by selling the fish.

At Vatukarasa, 75% 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 caused by 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 s*evusevu* with the Tui Navitilevu, Ratu Isikeli Vakabaletabua and interview with the Taraga-ni-koro, Joseva Qiokata, and other residents at Navuniivi, the paramount village in the *i qoliqoli*. The *i qoliqoli* vanua's are Navitilevu and Nagilogilo, which encompass the southeastern shore of Viti Levu Bay and extend offshore toward Vatu-I-Ra Passage. 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 Fisheries Division considered the amount of coral being stockpiled as excessive and stopped the collection. The collectors were delighted at the opportunity to collect the coral and utilized 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 Co. that this material was far in excess of their capability to export in a timely manner. The village collectors who would have preferred to continue collecting shared disappointment. 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.

There are several management problems with this business. No prior assessment was made of the resource and no environmental impact assessment was conducted. 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 unsuitable for sale due to its large size or damaged condition. The collected material was stored on a black sand beach and exposed to contamination and weather rendering some of the product unsaleable.

7.0 MANAGEMENT RESPONSIBILITIES

Discussion of the nature of coral product removal is at times polarized due to the uncertain nature of the fishery. The product collected has only been conducted, 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 *i 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 them 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 within the rights of customary marine tenure of the *i qoliqoli* and with the Fisheries Divisions under authority of the Fisheries Act. This sharing of the responsibility for management of the customary fishing rights areas has been a workable arrangement since the time of Cession (1874) though there was 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.

7.1 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 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 mean high water neap tide 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 by Sir Arthur Gordon in the new colony, 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 that 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 *i 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 was some uncertainty after Cession regarding 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 and 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 compensation system, established in relation to mangrove and foreshore reclamation, requires a developer to recompense 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 compensation sum is held in a trust fund and only the interest is paid to present and future generations of customary right owners.

7.2 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 compensative 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 minerals extracted from within customary fishing rights areas are paid to the rights holders. There is a depth limitation that effectively precludes royalties on such resources as gas and oil.

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 are, 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, while 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 *i qoliqoli* custodians for the collection of product.

7.3 Fisheries Division

Responsibility for fisheries matters lies with the Ministry 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 (1985). Chapter 158, the Fisheries Act, recognizes the Fijian people's customary right to fish in traditional fishing grounds (***i 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 these 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. The 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. The 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 are centered on the prevention and detection of offences under the Fisheries Act and the enforcement of the provisions of the Act (FFA, 1994).

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. Kailola (1995) pointed out that the management was "generally passive, sometimes rising to reactive".

7.3.1 Fisheries Regulation

The Fisheries Act does not specify the aquarium or curio products at present considers coral as an "...aquatic animal whether piscine or not...". Under the definition of "fish" in the Fisheries Act, it is subject to the various restrictions on the 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 (FFA, 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).

7.3.2 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 may represent associates who collect as a team. A general fishing license cannot be used to collect coral if it was issued for finfish. The exporter must comply with the fisheries directives and guidelines or an export permit will not be issued. (See Section 9.3)

7.3.3 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.

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

1. An approval in writing be given by its legal authority (*i qoliqoli*) and endorsed by the provincial administration;
2. This approval is to be forwarded to the Fisheries Division.
3. 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.
4. 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.
5. Collection activities should not concentrate for too long in any one site or area.
6. Collection should concentrate in areas of good growth, preferably on barrier reefs not shoreline reefs that are characterized by low pool due to inshore effects.
7. Actual (continuity of) coral harvesting for trade or business will be dependent on the favorable outcome of the survey report. Periodic monitoring will determine whether the harvest is sustainable.
8. 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.
9. Such license may exclude harvesting in certain areas claimed and registered by the Native Fisheries Commission to be known as *kanakana* (subsistence) of the Mataqali.
10. Local resource custodians are to do the collecting. The company's part in collection activities is marketing, training and advisory.
11. 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 *i qoliqoli* to facilitate communication)
12. The buying company is to make sure that collectors know which varieties and grades are acceptable to the company. This will minimize over-exploitation and wastage.

13. 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.
14. The Fisheries Division will not become involved in any financial dispute between the collector and buyer.
15. The failure to abide to the above guidelines will automatically result in the cancellation of the fishing license.

7.3.4 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 the requirements of the varied fisheries inshore as well as those offshore. A firm policy is now being developed for regulation of the industry with penalties for policy infractions. The ability to monitor the varied operations needs to be enhanced. Itemized are the principal problem areas:

1) Communication with the industry management needs to be improved. Responses to queries need to be made in a timely manner.
2) Resources at the Fisheries Division do not allow for adequate monitoring. Monitoring capabilities 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 *i 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.

8.0 ENVIRONMENTAL IMPACT ASSESSMENT

Little research as been conducted on the extraction of coral from the coral reef system (Joanott and Bour 1988; Ross 1984; Vaughan (in prep); Tjallingii and Douven (in prep)). In the absence of a complete understanding 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 of 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.

8.1 Live Coral

The positive and negative aspects of an environmental impact assessment on the fishery are summarized as follows:

- 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 provides a situation whereby areas of accessible collection are seeded by other reefs.
  4) Remoteness of the collection areas

- Problems 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 *i 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.

Vaughan (in prep) quantifies the effects of the collection of live coral for the aquarium trade on wild coral populations in Fiji. In his study, he surveyed a coral reef to identify the cumulative impacts of coral collection activities that had occurred over seven years. Reefs areas subject to collection activities were compared to areas without collection. No significant differences existed in the diversity of corals or substratum composition between the areas although the size frequency distribution of corals was significantly different and there were indications that collection reduces coral cover and alters species richness and evenness. He used a sustainable harvesting model used for natural forestry management and has adapted it to establish the a sound theoretical and empirical basis for the assessing a sustainable level of live coral that can be harvested.

8.1.1 Post-Collection Product Impact

Even when collected in an environmentally sound manner, aquarium organisms may suffer from poor husbandry practices such as improper handling, inadequate facilities, poor water quality during storage and transport, and high packing densities that result in reduced survivorship. Unnecessary mortality from destructive collecting practices and poor husbandry leads to added pressure on coral reefs as more organisms are collected to make up for those that die during collection, during storage or transport, or soon after being sold. At the collection level the marine ornamentals industry may also produce negative socio-economic effects by undermining other reef use practices and failing to equitably distribute financial benefits.

8.1.2 Quota System

There are some species and groups of marine organisms that may not be appropriate for commercial harvesting. However, this will be an evolving situation, as the knowledge of the biology and ecology of reef species advances, along with the ability to keep species in captivity. At the current state of the art and knowledge, species that should be considered as inappropriate for the trade include those that:

- Are rare or endangered in the country or in the region,
- Have particularly important ecological roles, e.g. cleaner wrasses, cleaner shrimp;
- Are generally very difficult to keep and do not survive well in captivity, e.g. cleaner wrasses, nudibranches;
- Have specific or difficult feeding requirements and therefore are generally very difficult to keep and do not survive well in captivity, e.g. butterfly fish that feed only on corals; and
- Provide specific habitat for other species, e.g. anemones that have a symbiotic relationship, and are required for clownfish to survive.

8.2 Giant Clams (*Tridacna spp.)*

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

Wild caught specimens for export contravenes the Fisheries Act, which seeks to protect domestic food items. The small number of clams collected is 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.

8.3 Live Rock (Figs. 2-4a-h)

Live rock removal is the mining of reef rock that 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 that 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, sand and rubble characterized some reefs. Areas in the proximity of creek outfalls exhibited a preponderance of algae. They were characterized 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 luxuriant 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.

Aspects which are conducive to 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 *i qoliqoli* are used so the potential adverse effects are limited.
    b) Best practice methods are peripheral to luxuriant coral areas (e.g. lagoon) occurring in such habitats 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 (microhabitats).
3) Conflict with tourist operators who view the collection as reef destruction, compromising a valuable asset.
4) Presents a poor conservation image.

In considering the above points, it is clear that if a code of practice is adhered to then the environmental impact will be minimized. A favorable economic return, particularly at the village level gives the industry additional acceptability. 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 outweigh the potential negative consequences. The extraction is carried out in only a portion of the *i qoliqoli* and has provided continuous work for several years with abundant material remaining.

To accurately assess the state of the reef flat fishery, reliable data needs to be gathered. Coupled with periodic monitoring, this would allow for a more complete understanding of the consequences of such large-scale removal from the patch reefs in the inner lagoon. Studies elsewhere, have shown that both abundance and diversity of fish are reduced as the result of such disturbances.

8.4 Curio Coral

The main points that apply to the live coral collection also apply to the curio coral. An important distinction is that the curio coral takes a much wider range of colony sizes. Collection is largely of the fast growing *Acropora* species as well as substantial amounts of other genera (Appendix 14.1) and is generally to order. There is good recruitment yearly but many 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 other 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 or resource assessment of the standing crop prior to harvest will provide a basis for determining 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 required for trained personnel as well as the difficulty of monitoring, make management guidelines much more important.

The advantages and problems of the curio collection are much the same as the aquarium trade in a categorical sense. The main differences lie in the broad size range that is being collected and the amount of material that is being collected. Assessment of the impacts of these differences requires a more detailed assessment.

- Positive considerations that promote sustainability are:
  1) Extensive collection areas
  2) Shallow collection and collection of particular species and commercially suitable specimens allow for abundant material for recruitment
  3) Remoteness of the collection areas

- Problems of collection are difficulties in:
  1) The product has a broad size requirement
  2) It is a resource of unknown abundance
  3) The life history role of the corals are incompletely known
  4) Monitoring the impact of the fishery on the reef system or *i qoliqoli*.
  5) Cost of monitoring
  6) Tourist and village conflict exists

The companies engaged in curio collection are Seaking Trading Co. and Acropora International operating near Viti Levu Bay and in Bau Waters respectively.

- The following points summarize the main requirements in an environmental impact assessment on the fishery:
    1) Knowing the abundance of material available for collection
    2) Knowing the general biology, particularly, the growth rate of the species to be removed
    3) Assessment of the ability for the coral to re-establish
    4) Foreseeing the 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* that are fast growing and prolific recolonizers. Collection is limited by the prohibition of underwater breathing apparatus, which prevents taking material from deeper water. The decorative nature of the coral product necessitates only the utilization of attractive pieces, discouraging the collection of damaged or mis-shaped specimens. Larger specimens are not normally collected. The uncollected material is in far greater abundance than that subject to collection.

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 unregulated collection. 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 village embraces the activity and the *i qoliqoli* is large, this is less of a concern. In Bau Waters, where the boundaries of the area are more confined and many villages share the finfish fishery, there is a hesitation by the non-participating villages to believe that the activity is non-destructive.

The curio trade is the most problematic, as conceptually, it appears that over-collection may take place. Thus 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 compiled. From this, an adequate monitoring regime could be developed.

8.5 Misconceptions

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 reefs is so variable. The artificial removal of a component of the hard coral from a reef community would still leave an assemblage that would be difficult to discern from the range that 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. The largest colonies or the encrusting colonies are not removed. 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 reef structure is largely the result of cementation of coral skeletons by calcifying 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 characterized 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 resistant reef zone where the reef crest is characterized by an algal pavement and buttress system creating an impenetrable barrier against the force of waves. This zone is tens of metres thick. On the reef slope, the coral presence

increases and becomes more luxuriant with depth. It is in this seaward area that much of the rubble originates and 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 or the utilizing of the subsistence fishery. Pressure will always be on high value organisms whether from harvesting crews or general fishing. The area harvested is from the *i qoliqoli* in which the resource custodians have the right to collect. Considerations of over-fishing of reef organisms may occur but general fishing pressure is far greater than the contribution during the coral collection period.

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).

8.6 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 coral biology and ecology as applied to collection from discrete areas. Our knowledge is often only categorical, with much of the detail of the organisms life histories unknown.

The standing stock of coral products for the aquarium or curio trade varies in 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 widespread 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 that can potentially provide recruitment to exploited reefs, coral stocks in the Pacific will be resilient to extraction. There has been no generalized 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 trans-shipped material for all coral related products, there has been a consistent increase in the amount of export since 1997. 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 and Engel 1979). 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 one's neighbour 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. 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, protection 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 however, 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 13.4) and would take decades to re-establish. Collection of these in New Caledonia from a limited reef area was determined to be twelve times the sustainable level (Joanott and Bour, 1988).

Harvest has been likened to logging in that natural abundance or the standing crop of species is removed. 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 popular corals taken are fast growing (Appendix 13.4). The size categories taken are generally small to medium size colonies only. 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 are annual spawnings 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 an aquaculture point of view, the slow growth rate of corals does not make economic sense if the option for natural exploitation exists. The question of aquaculture and husbandry of coral are now being investigated (see section 11.9).

A consequence of too much coral being removed from an area is the reduction of recruitment potential 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 10.2) and confirmed through regular monitoring.

For aquarium coral, Green and Shirley (1999) concluded that trade may be sustainable and that the 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.

8.7 Socio-Cultural

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. 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 employed. Confiscation of vehicles has occurred by villagers who objected to the collecting in their *i 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 who began taking live rock from the adjacent *i 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 making whether to proceed with the business receives the largest percentage of the payment for the extraction. He may also be the license holder.

8.7.1 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 can be gained over a two year management implementation and monitoring period and allow for management adjustments to be made at that time. The current report has recommended that there be no additional entry into the fishery by 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 sectors rely both on the market, the ability to successfully conduct business and the availability of the resource.

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 and from 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 the airport. Without 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 along the south coast of Viti Levu. This is because the wave action promotes good coralline algae growth. 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.

8.8 Legal

The Fisheries Act (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 curio coral fishery are through the Fisheries Division guidelines on coral harvesting.

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

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 introducing regulations and amending the Fisheries Act.

2) The system of licensing needs review. The currently 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 have been utilized for live coral collection. The present system conveys the right

to fish a resource, common to the Vanua, to a single person. Though illegal under the Act, this practice empowers the license holder to control both access to the resource and the employment in utilizing 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 management control 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 in issuing 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/her discretionary 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.
Licences should attract a fee of $500 and the granting of export permits $25.

5) With reference to the Coral Harvesting Guideline no.14 that states, “the failure to abide by the above guidelines will automatically result in the cancellation of the fishing license”. This should also include 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 when 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 standardized 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 *i qoliqoli*. This issue 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 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 placed the decision to exploit the resource into the hands of the local custodians, while the Fisheries Division role was to keep track of harvesting and provide management advice. Many of the Guidelines were superceded in December 1988 when Cabinet passed a new legislation banning the export of giant clam meat. Regulation 25A of the Fisheries Regulations (Cap. 158 as amended) states 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).”

8.9 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 have provided a number of incentives to encourage the companies to move their operations to Fiji.

The increasing demand for coral reef aquaria increases awareness in overseas markets of the wonders of the coral reef environment. With Fiji having 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 some products associated with Fiji. *Fiji* Live rock has a good reputation and is a preferred product for natural habitat in aquaria.

9.0 International regulation: Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Proposed US Legislation.

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, signatories to CITES, are obliged to honor 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 and Wood, 1989). The listing was 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 however, a possibility (Guzman, 1991; Ross, 1984). As collection in some cases is from discrete areas such as relatively small *i qoliqolis*, the localised depletion is likely for some organisms but were collection to cease, it is probable that their populations would re-establish.

9.1 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.

9.2 The United States and Its Role in the Trade of Coral Reef Organisms

The United States is the world's largest importer of coral reef organisms for the marine aquarium industry. As such there is a perceive responsibility to ensure that the trade is conducted in a responsible manner. This means that it is done sustainably and that best practice methods are used and improved on to insure that the condition of the collected organisms remains high and that mortality is kept low. A regulatory framework for the trade has been lacking largely because the information and science that surrounds the industry has been slow to keep pace with its development. Coral reef trade legislation would be a significant step to ensure that collection of coral reef organisms is sustainable and non-destructive, and utilizes best handling and transport practices.

The United States has been consistently the largest importer of hard corals and reef rock ("live rock") during the 1990s. Over 80% of the live coral, 95% of the live rock and 50% of the dead coral in international trade is imported into the U.S. each year, and the global trade in corals is increasing at a rate of 10-20% per year. In 1997, over half a million corals and 600,00 kg of live rock were imported into the U.S. Ironically, the U.S. either prohibits or strictly limits the extraction of hard corals in most of its own federal, state and territorial waters, because of widespread concerns that the organisms are vulnerable to overexploitation. This largely due to the most US flagged coral reef areas being in the Caribbean where the species diversity is low and a yet to be explained die-back of hard corals and other organisms is occurring. In the Pacific, much of the US coral reef area which would be subject to aquarium collection is high latitude and unsuitable for collection due to is low diversity and general lack of luxuriance. Also there is not the need to utilize a resource which has not been fully evaluated in terms of its potential for harvest. Alternative employment is more readily available and social welfare provides a safety net, by contrast, coastal villagers have few opportunities except to maximize the value of their reefs. Precaution is certainly appropriate, in both cases, though there is a more pressing need in the cash limited village to understand and rationally maximize the resource.

U.S. legislation is a responsible step towards promoting good management and practices in this international industry. Members of the aquarium industry and environmental organizations have supported the efforts of the Marine Aquarium Council to develop a certification system to ensure that these products are sustainably collected and responsibly handled and transported. Within the larger picture of coral reef conservation, this action is needed to limit unsustainable collection of some species, prohibit the use of destructive fishing practices, support the development of an ecosystem-based approach to resource management, and encourage the adoption of sustainable use practices for coral reef resources worldwide.

9.3 Conceptual Outline of Coral Reef Legislative Proposal

Following is an outline of the proposed US legislation to regulate the importation of aquarium organisms into the United States. It is the result of the Coral Reef Task Force's International Trade subgroup deliberations, which involved wide-ranging considerations to address the US Presidents Executive Order #13089 for the Protection of Coral Reefs. Success of this legislation relies on the presidential party, after the November, 2000 elections, presenting the legislation before Congress in 2001.

9.3.1 Interstate Commerce or International Trade in Coral Reef Species

1. Except as the Secretary may allow, the domestic harvest or collection, import, export, or re-export of CITES-listed coral reef species is prohibited, as of a specified period of time after enactment. Also, the possession of and interstate commerce in illegally harvested, collected, or imported CITES-listed coral reef species is prohibited. The Secretary will have the authority to extend this prohibition to non-CITES listed coral reef species if the Secretary finds that the harvest or collection, import, export, or re-export of such species represents a substantial risk of harm to the sustainability of such species or of coral reef ecosystems, or results in high mortality rates to those species due to poor survivorship in transport or captivity. (The term "coral reef species" will be defined in the legislation; it will include hard and soft corals, ornamental fish, but not food fish.)

2. If any additional coral reef species is listed under CITES Appendix II, it shall be covered by the prohibition in paragraph 1 unless the Secretary finds within a specified period of time from the date of listing that the interstate commerce, import, export, or re-export of that species does not represent a substantial risk of harm to the sustainability of that species or of coral reef ecosystems.

3. The Secretary will have the authority to delist coral reef species that are covered by the prohibition in paragraphs 1 and 2 upon a finding that the interstate commerce, import, export, or re-export of that species does not represent a substantial risk of harm to the sustainability of that species or of coral reef ecosystems.

4. The Secretary may allow a company, organization, or individual to engage in the domestic harvest or collection, import, export, or re-export of prohibited species on grounds to be defined in the statute, such as when harvested in accordance with an approved plan providing for the sustainable management of the species, an approved captive breeding program, or intended for scientific research or public display.

5. The Secretary will work with stakeholders (for example, industry, states, territories, local entities, tribes, NGOs etc.) to develop and promote within a specified time period criteria and indicators for transportation and handling of coral reef species that ensure survival in captivity.

9.3.2 Destructive Fishing Practices

1. Effective as of a specified period of time after enactment, the domestic harvest of any coral reef species through defined practices destructive to the ecosystem is prohibited. The legislation shall define an initial list of the prohibited destructive practices, such as the use of reef-dredging, explosives, or poisons. The Secretary may add others to the list, under statutory criteria. Any allowance pursuant to paragraph 4 for domestic harvest and collection of species must be conditioned on compliance with the prohibition on harvest via destructive practices and/or accompanied by a certification that they were not harvested or

collected through destructive practices**.**

2. Effective as of a specified period of time after enactment, the import or export of any coral-reef species is prohibited unless accompanied by a certification from the country of origin and/or the importer/exporter] that the imports or exports were not taken through the use of the destructive practices prohibited under paragraph 6. If the Secretary determines, after notice and opportunity for a hearing, that an importer/ exporter has imported/exported items accompanied by a fraudulent certification, that importer/exporter shall be subject to sanctions including being barred from importing/exporting any additional coral-reef species.

9.3.3 Sustainable Management

1. The Secretary will work with stakeholders (for example, states, territories, local entities, tribes, industry, NGOs etc.) to develop within a specified time period criteria and indicators for conservation and sustainable management of coral reef ecosystems.

2. Upon completion of paragraph 8, the Secretary will work with stakeholders to develop within a specified time period a coordinated national strategy for conservation and sustainable management of coral reef species and ecosystems.

3. The legislation will include provisions that will encourage the development of criteria and indicators and a coordinated strategy for conservation and sustainable management of coral reef species and ecosystems in other parts of the world, such as through multilateral negotiations and participation in various international fora (such as ICRI and APEC.)

4. Technical assistance and capacity building will be authorized to support the steps in paragraph 10 and the sustainable management of coral reef species and ecosystems generally.

9.3.4 Appropriations

12. The legislation will include authorization of appropriations to the Secretary of the Interior, Secretary of Commerce and Secretary of State to carry out the provisions of the Act.

> " 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 outweighs the benefits, then the activity can be stopped. The reef has always been seen to be resilient, particularly in recovery from cyclone damage, so it is likely to restore itself. Part of the management problem is whether the collectors might impact on other village reef users who receive no benefit from the enterprise.

10.1 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 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 *i 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, providing awareness and expertise in its assessment.

10.2 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, encompassing the information in the above points.

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

Joanott and Bour (1988) conducted an example of surveying the coral resource. In this study, the biomass of the coral for the family Faviidae was 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

10.3 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 that 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.

10.4 Stock Management Plan

Maximum sustainable yield (Bouard and Grandperrin, 1985) 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 authorized" (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 and Holt, 1957) to assess the status of the deeper water, precious coral fishery. Using data from Ross (1984), 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 *Pocillopora 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 *i 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 that 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.

10.5 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 the exporters, who seek only permission from the custodians only 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
(5) Lack of notification of utilizing 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 conserve stocks.
2. Accountability is not possible when multiple companies use the same area. Problems of damage, over-collection or infraction of the 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 unacceptable as employees if they are chronic offenders of proposed Fisheries regulations. 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 so an area will remain productive in the future rather than a strategy of encouraging over- and inefficient collecting. With two operators, the commercial reality will minimize conservation efforts, as the product will always be threatened by the competitor with the philosophy of "get it before the other guy".
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 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.

10.6 Recommendations for Penalties for violation of Proposed Fisheries Guidelines (Lovell and Tumuri, 1999)

A regime of fines is 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 for adherence 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

10.7 Industry Association: Aquarium Traders and Curio Coral Council

A more effective way of managing the industry is through consultation with exporters, Fisheries Division and the Environment Department. The Aquarium Traders and Curio Coral Council was formed during 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. A chairman has been elected and periodic meetings have been held though its constitution has yet to be ratified.

10.8 Standards Association for Aquarium Products Collectors: The Marine Aquarium Council - certifying quality and sustainability in the marine aquarium industry (Adapted from Holthus (2000)

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.

Government agencies, industry, and NGOs have made isolated attempts to address the impacts of the marine aquarium trade. No single government or other party has been positioned to work with the full "chain of custody", the range of other stakeholders, the global consumer demand for marine aquarium organisms, and coral reef conservation issues.

In response to this, the Marine Aquarium Council was established as an international multi-stakeholder institution to address the situation comprehensively and achieve market-driven quality and sustainability in this industry by developing an international system of certification and labeling for quality and sustainability in the marine ornamentals trade. This will include developing standards for quality products and sustainable practices; providing a system to document compliance with these standards and label the results; and creating

consumer demand for certified products and practices. The Council began as an initiative of a cross section of organizations representing the aquarium industry, conservation organizations, public aquariums, hobbyists, scientists and others concerned with:

- 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 fishers 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.

Participation in the Council continues to be open to those interested in contributing to a constructive dialogue concerning the development of market incentives and a certification and labeling system to achieve this goal. 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., WWF, and The Nature Conservancy. MAC partners and supporters include major international and regional conservation organizations. It is envisaged that the MAC will evolve into a largely self-financed system based on improved economic return from certified marine aquarium organisms, consumer willingness to pay for these organisms, and industry willingness to pay for certification.

♦ 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 outline plan for the development of certification through MAC has been completed and are as follows:

♦ Phase I: Multi-Stakeholder Initiative (1996-1998)
Introduce the certification and labeling concept; establish broad initial stakeholder support and participation; develop and communicate the certification initiative; establish multi-stakeholder steering committee.

♦ Phase II: Certification System Development (1998-2000) is underway
Broaden stakeholder network; develop and test standards, certification guidelines and procedures; begin to create consumer awareness and demand; undertake initial certification in pilot operations, establish an independent, multi-stakeholder institution to catalyze, facilitate and coordinate certification and labeling.

♦ Phase III: Initial Implementation (2000-2001)
Implement certification on a significant scale in major source and market countries; expand consumer awareness and demand; expand certification capacity in relation to ability and willingness of market and industry to support it.

♦ Phase IV: Financial Sustainability (2001-2003)
Achieve critical trade volume and level of consumer demand; consolidate principal funding of certification

through market and industry willingness to pay for added value; ensure adequate on-going external subsidy to certification of smaller operations.

- Phase V: Mainstream Operations (2003-ongoing)
  Fully integrate certification as the basis of the industry; fulfill stakeholder interests in improving and expanding the standards and certification; transfer experience and lessons to other certification and fisheries areas.

The Director of the MAC has made presentations on the development of certification and labeling and its importance to marine resource conservation, management and sustainable use at several key gatherings in the South Pacific region. At both the 1998 SPC Regional Technical Meeting on Fisheries (October 1998) and the Forum Secretariat/SPREP Seminar on Trade and Environment (January 1999), fisheries, environment and trade officials from the region expressed considerable positive interest in MAC and certification. MAC has also been asked to collaborate with SPREP in the delivery of a training workshop in 2000 to establish a permitting system to manage and monitor the coral trade in the region. This activity will work hand in hand with certification system being proposed under this project.

The Forum Secretariat, in collaboration with MAC, prepared a report in June 1999 that indicated it is possible to have a trade in marine aquarium organisms in FICs that is based on quality, sustainability and environmentally and socially sound practices. The proposed project is urgently needed to assist the region in addressing the controversy and concerns over the sustainability of the marine ornamentals trade. For example, in Fiji in July 1999, the debate over the impacts and sustainability (Lovell and Tumuri, 1999) led to hearings by the environment and fisheries ministries to try and determine the impacts, sustainability and management of this industry. As a result, the government has limited the industry to the current operators until there are standards of practice, government regulation and monitoring. The project proposes to work with the governments on addressing these needs.

10.9 South Pacific Marine Ornamentals Certification Program: Forum Secretariat and MAC

The South Pacific Forum Secretariat and the Marine Aquarium Council has initiated a program to implement the marine ornamentals certification for aquarium collection within the South Pacific region (August 1, 2000). The project manager has been hired with the responsibility for developing a multi-stakeholder network, organising and facilitating meetings and consultations.

10.9.1 The Program

The Marine Aquarium Council (MAC) will take the lead role in implementing activities to develop a third party marine ornamentals certification system for Forum Island Countries (FICs). This project is focused specifically on addressing the range of negative environmental impacts that are occurring, or may occur, in conjunction with the existing marine ornamentals industry. It will focus on three FICs (Fiji, Cook Islands and Solomon Islands) and introduce a market driven certification and labeling system for its marine ornamental industries that will assist countries achieve a balance between developing profitable reef-based industries, maintaining reef health and minimising environmental impacts. The expected outcome of the project is compliance by a significant portion of the marine ornamentals industry in the target FICs with the independently verified standards for quality and sustainability that have been developed in partnership with governments and other stakeholders.

a) Accounting for Employees

There is limited data on the actual number of men and women involved in the marine ornamentals trade at the collection and export levels, or if and how collection activities are having differential impacts on men and women at the village level. The project will gather information to address these gap areas. It will also ensure that there is gender balanced village stakeholder participation in national workshops and networks.

b) Benefit Driven

It is clear that the marine aquarium industry can provide high quality, healthy aquarium organisms with minimal mortality harvested from a sustainably managed reef environment, as well as good, equitably distributed returns to village communities. This is exemplified by successful industry operations that operate in this manner and are ready to provide information to back their claims. Indications are that hobbyists would prefer to support this kind of industry. However, there is currently no system in place to identify and document quality products and sustainable practices and allow the consumer to reward those in the industry operating on this basis.

The demand from informed consumers for environmentally sound products could provide incentives for industries to adopt and adhere to standards for quality and sustainability. The single most important market force in the marine aquarium industry is the purchasing power of hobbyists. Market assessments show that there is a strong demand for certified marine aquarium organisms and that this demand will increase rapidly when there is a comprehensive, independent certification system. At the same time, marine aquarium organisms from uncertified sources will face decreasing market acceptance and destructive and substandard practices will decrease as these operators either adjust their practices "upward" to comply with certification standards or lose market support.

10.9.2 Project Description

The Marine Aquarium Council (MAC) will be the lead agency for this project component. The Forum Secretariat, Pacific Community, South Pacific Regional Environment Program, the University of the South Pacific, World Wildlife Fund for Nature, ICLARM and other organizations will play advisory and/or technical support roles.

Using the services of a regionally based manager, this project component will undertake activities in three FICs over a three-year period. The FICs tentatively targeted for inclusion in the project are Fiji, Cook Islands and Solomon Islands. These three countries have been selected because they each have established marine ornamental export operations underway at different stages of development, and each of these industries have established contact with MAC. Fiji has the most well established ornamental export industry, with five companies now operating. With extensive reef area, regular air connection to many of the major markets of ornamentals and a reputation for quality products, the Fiji situation represents the challenges for developing sustainability in a well developed Pacific ornamentals industry situation. Cook Islands has a single, small ornamental export operation faced with many of the logistical difficulties characteristic of much of the region. Concerns have been raised about the social and environmental effects of village-level collection practices used in both of these countries. In the Solomon Islands, village-based grow out of cultured clams and the culturing of coral reef fragments for the aquarium trade have begun. Village based culturing is a potentially important component of the future of sustainable ornamental industry in the region. In the event that key stakeholders in any of these countries are unable to participate in the project, other FICs involved in the export of marine aquarium animals will be approached to take their place. The MAC network already includes interaction with Vanuatu, Tonga, Federated States of Micronesia, Palau and the Marshall Islands. Industry operators and government officials in these countries have also expressed interest in developing and implementing certification.

The Fiji-based Project Manager will coordinate implementation of the marine ornamental component of the project for the three countries. MAC infrastructure must remain lean and focussed on coordinating and working though the MAC network to establish partnerships and in-kind commitments resulting in significant leverage of the investment in core staff.

The project will be implemented using a two step process. Step 1 will comprise two activities: (i) national consultations and workshops and (ii) national industry profiles. Step 2 of the project will proceed upon

agreement by national governments and stakeholders to pursue industry certification and labeling as a strategy for enhancing the sustainability of their respective marine ornamentals trade, and include two further activities: (iii) certification testing, and (iv) information, training and accreditation.

10.9.2.1 National Consultations and Workshops to Develop a Stake-holder Network

Certification for the marine aquarium industry involves a complex mix of stakeholders, as well as the tremendous cultural, social, economic, environmental and political diversity of each country. Individual or small group consultations are often required to establish familiarity with certification among stakeholders. Multi-stakeholder workshops are an important step to develop interaction among stakeholders and establish the common ground needed for developing and implementing certification.

MAC has conducted consultations and workshops in 1997 and 1998 in key aquarium industry export and import areas, including the continental U.S., Hawaii, and the Philippines. Under this project, the Project Manger and the MAC Director will undertake consultations with the range of industry and other stakeholders in the target FICs. An initial one-day national workshop will subsequently be held in each country to:

- Share lessons learned from marine ornamentals industries in the other parts of the world;
- Provide an opportunity for multi-stakeholder discussion on the key national issues posed by the marine ornamentals industry and strategies for addressing these concerns, including certification;
- Improve stakeholder understanding of MAC and identify key issues, difficulties, solutions and priorities for certification in the country;
- Initiate the development of a marine ornamentals network in the country; and,
- Obtain stakeholder input on priorities and a work plan for completing the industry profiles.

Establishment of an on-going national marine ornamentals network will maintain interaction among stakeholders and foster their involvement in developing and implementing strategies for addressing key areas of concern related to the industry, including options such as certification. The participants in MAC consultations and workshops will form the basis of the network in each country. The Project Manager will maintain regular communications among the stakeholders in each country, particularly industry participants.

10.9.2.2 National Marine Ornamental Industry Profiles

There is limited current information available on the marine ornamentals resources, or industry practices, costs and benefits in the three target FICs and therefore a need to prepare a comprehensive picture of the existing situation. The profile will include:

- industry operators and practices;
- distribution of export species;
- volumes and values harvested and exported;
- the socio-economic situation and impacts in collection areas;
- the environmental impacts associated with collection;
- an analysis of sustainable production opportunities (e.g. aquaculture);
- an indication of resource management options (e.g. limited entry permits, harvest quota systems);
- and, the feasibility of certification for the marine ornamentals industry in the country.

This information, in particular data related to existing collection practices and village/reef level environmental, social and economic impacts, provides the foundation on which to review and test the draft standards and certification system.

Progressing to the second stage of the project will occur for those countries that are committed to maintaining a marine ornamentals industry and make a formal written request of the Secretariat to participate in a certification and labeling program. A second one-day national workshop involving stakeholders will be convened to facilitate this decision. The workshop will review key issues posed by the ornamentals industry, new information prepared through the profiling exercise, discuss key issues, difficulties, solutions and priorities for certification in the country and identify companies and communities interested in participating in certification testing.

10.9.2.3 Testing of Draft International Standards and Certification System

A solid, credible international system of standards, documentation, certification, and labeling is the core of achieving the goal of the project's second stage. To compel industry involvement and create tangible results early on, an initial working version of the certification system must be up and running as soon as possible, building on the draft international standards and certification system that MAC is developing. The draft standards and system will be reviewed by a South Pacific Working Group composed of individuals from the MAC networks in the participating FICs, and representatives from regional agencies and other interested organisations. The standards and certification system will be adapted to reflect the South Pacific situation and special issues, while maintaining their integrity to serve as "umbrella" standards for the industry internationally.

Industry members from the MAC networks in each country that are willing to contribute time and effort to certification development will undertake testing of the certification system. The testing will be conducted through trial runs of the certification standards along "strands" of the chain of custody from collection-to-retail. This will include collectors, producers of cultured aquarium products, and exporters.

The collectors and aquaculture operators will run their operations according to the standards and then pass them to the exporters, who will also run their operations according to the standards. A key part of the trial runs will be to test the capacity of the industry to operate according to the standards in real-world situations. The trials will also test the "cross-cutting" aspects of the certification system that link the collectors (or aquaculture operators) and the exporters, especially the product tracking and documentation system.

The testing will begin with collection-to-export strands in the participating FICs. At the same time, MAC will be conducting tests in the Philippines, Australia, and Hawaii. The products exported from these test runs will feed into import-to-retail test runs in North America and Europe. The tests in the South Pacific region, along with the other pilot areas, will ensures that trials are run in a sufficient number of areas and conditions to ensure that variation in different situations is adequately accounted for.

The results of the testing in the South Pacific region will be revised by the South Pacific Working Group and revisions recommended. These recommendations, along with those from the other test areas, will be synthesized by the MAC International Working Group and a revised version of the standards and certification system developed. The testing and revision process may go through several iterations before the certification standards and system are considered ready for implementation.

Implementation of certification and labeling will begin when the certification standards and system are made publicly available and companies are invited to submit applications for initial certification audits. However, launching the certification system will require supporting information and training services.

10.9.2.4 Informing, Training and Accrediting Industry Participants in the Certification System

Because certification is new to this industry, documents that clearly explain the standards, documentation system, etc. will be developed and distributed. This includes manuals that guide industry participants through self-evaluation procedures and explain how to upgrade systems and practices to achieve "certifiable" standards. A MAC international working group will be developing initial information materials. These will be reviewed by the South Pacific working group and revised to reflect conditions and needs in the region.

Materials for training industry personnel will be produced to facilitate industry ability to comply with certification. This will include training materials for collectors and MAC will need to actually provide training for some parts of the industry, such as collectors. Wherever possible, training will be conducted by MAC network members with existing expertise in training.

Actual certification will be undertaken by accredited certification agencies that have proven their qualifications to apply, monitor, and audit the use of the MAC certification system. Accreditation criteria will be developed by MAC and will be reviewed by the South Pacific Working Group to ensure they are relevant to the South Pacific region.

10.10 Coral Aquaculture

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.). Aquaculture 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 European de Monaco, has looked at the possibility of culturing various species of corals in aquaria. (Jaubert et al., 1996). Marine aquarium clubs regularly exchange organisms reared in their private systems. Some private individuals have commercially grown coral from which pieces are fragmented for sale.

10.10.1 Industry efforts

Walt Smith International is attempting to grow corals on racks at Naviti I, Yasawa. Construction is in progress to double the size of his warehouse facility to begin the aquaculture of selected organisms. An aquaculturalist is being sought to oversee this operation as well as post-graduate participation from the University of the South Pacific.

10.10.2 Co-operative: A Village Based Industry

The opportunity exists for the aquaculture 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 is supporting experimental cultivation of coral. This is occurring at the village level near Kamba in Bau Waters at the village level and has plans for expansion to other locations in Fiji.

10.10.3 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 student's 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 degree programs 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.

11.0 RECOMMENDATIONS (after Lovell and Tumuri, 1999)

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.

11.1 Actions and Guidelines

1) Creation of 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 as this 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 10.2).

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 and 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 analyzed 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 *i 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 or 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 requiring research confronted by the Industry.

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

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.

11.2 Collection of live coral and other fauna

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

2) Collection must be of whole colonies only with the fragmenting of larger colonies into smaller ones prohibited.

3) Require a commitment by industry participants to the aquaculture 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.

11.3 Collection of Live rock

1) Live rock resources to be subject to an environmental impact assessment and Fisheries Division approvals.

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

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

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

5) Utilize only a portion of the *i qoliqoli*.

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

11.4 Collection of Curio Coral

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

2) Waste from 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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13.0 APPENDICES

13.1 a) Classification or Taxonomy of Organisms taken for the 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 utilized in the production of local jewelry production. Not currently exported.

Order Actinaria — Sea anemone

Order Coralliomorpharia — 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

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

Phylum Porifera –Sponges

Phylum Annelida
- 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

13.2 Table 4: Species of Hard Coral Collected for the Curio Trade (After Viala, 1988; Lewis 1994)

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 tenuifora?	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
Meandua? 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	45	43880	41273	73238	6436	136,111

(?) refers to unclear taxonomic status

13.3a 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. 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:

13.3b Sample characteristics

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

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			

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			

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		

13.4 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 provide 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* *Plerogyra*	.5-.75 Mean range .5-.75	Massive with fleshy corallites.
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.

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Let's leave our children a living pacific

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