
Frontier Fiji Marine Environmental Research

TECHNICAL REPORT 4

A socio economic study of Gau Island, Fiji

Wells, E.

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Frontier-Fiji

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Table of Contents

1. Introduction.....	8
2. Fishing Activity	9
2.1 Subsistence Fishing.....	9
2.1.1 Fishing Method	11
2.1.2 Fish Catch	12
2.1.3 Fishing Location	13
2.1.4 Summary	14
2.2 Commercial and sport fishing	15
2.2.1 Fishing at Nigali.....	15
2.2.2 Other Commercial Activity.....	18
3. Impacts and Evidence of overfishing.....	18
4. Addressing Fishing Impacts.....	20
4.1 Scientific Studies - Monitoring	20
4.2 Management of fishing areas	22
4.2.1 Summary	24
4.3 Establishing Aquaculture and Mariculture Systems	25
5. Agricultural activities.....	26
6. Tourism.....	27
7. Natural Changes.....	28
8. Addressing impacts from land-based pollution.....	29
9. Recommendations.....	31
9.1.1 Communication with locals	31
9.1.2 Aquaculture.....	33
9.1.3 Education	33
9.2 Communication with other organisations	34
9.2.1 Scientific research.....	34

9.2.2	Baseline Survey Protocols	34
9.2.3	Restricted Fishing Zones.....	35
9.2.4	Workshops	35
9.2.5	Monitoring in Nigali	35
9.2.6	Monitoring Target Species and Indicator Species	36
9.2.7	Coral Bleaching.....	36
9.2.8	Socio-Economic Studies	36
10.	Conclusion	37
11.	References.....	38
	Appendix 1. Workshop details and questionnaire	42
	Appendix 2. Results from workshop discussions and questionnaires.....	47
	Appendix 3. Newsletter produced by Dr Emma Wells and Huygen Theodoor van Steen	56

1. Introduction

This report is based on personal observations and communications and includes information gathered as part of the socio-economic activities carried out by Frontier such as workshops and questionnaires. It aims to look at all aspects of the life style of the local villagers of Gau, how they utilise their marine and terrestrial resources and the subsequent impacts on the health status of the fringing reef, barrier reef and internal lagoonal ecosystems. Much of the information collected through the series of workshops (detailed in Appendix 1) held at 4 Villages along the west coast of Gau can be found in Appendix 2. Through this initial approach a newsletter was submitted by Dr Emma Wells and Theodoor van Steen to Frontier to summarise the progress made during these interactions (Appendix 3).

There are many aspects of the daily activities that impact both the local people and their terrestrial and marine environment. Some are natural and unpredictable changes, others are through development and natural progress. Table 1 broadly summarises the main issues faced by the local people of Gau and the potential solutions to such problems.

Table 1: Major concerns for conservation of marine resources into the next century in Oceania, adapted from Maragos (in Terry, 1998).

Issue	Solution
Overfishing and destructive fishing practices	Reassert traditional/community controls in populated areas, surveillance and detection in remote areas, severe penalties for violators, enhanced education and public awareness
Global climate change (bleaching, sea level fluctuations, cyclones, flooding)	Shoreline setbacks to protect coastal and marine ecosystems, population control and redistribution, ecosystem restoration, long-term quantitative ecosystem monitoring
Existing pollution and waste disposal impacts on reefs	Dispersion of sewage and location of outfalls outside of confined bays and lagoons, alternative technologies, solid waste reduction, recycling
The effects of coastal development	Environmental impact assessments and coastal resource management
Threats placed on rare and endangered	Establish and manage protected areas, modify existing regulations and increase

species and reproductive areas	enforcement regimes, public education and awareness, support for biodiversity research, enhanced long range ecological monitoring
General Degradation of ecosystems	Research and development on ecosystem restoration

2. Fishing Activity

One important issue for the population of Gau is one of worldwide concern that has already been experienced on a huge scale: the overexploitation of fishing or marine resources. Although this is not currently of major concern to the people of Gau this is likely to change in the near future with increasing fishing activity on both the fringing and barrier reefs from the local communities along with opportunist fishers from the main island of Viti Levu (Veitayaki and Murai, 2005).

Inshore marine resources play a vital role in the sustenance of Fiji coastal populations. Fish and shellfish are the main provider of protein and remain essential for the subsistence of the indigenous population in rural areas, with Fijians being among the highest seafood consumers in the world (Zann, 1995). But rapid population growth, introduction of modern fishing gear, degradation of coastal habitats, industrial pollution and uncontrolled commercial fishing operations have resulted in locally severe reductions of stock levels of fisheries resources, especially on reefs and lagoons closer to urban areas. Fortunately, the scale of human impact is considered to be low in the outer islands such as Gau (Ledua and Vuki, 1997).

The following section describes the fishing activities that currently take place on Gau. It looks to cover the primary fishing activity of subsistence fishing including general levels of effort and yield, methods currently utilised and how these may have changed over the last few years. Secondly, it reviews the pressures from sport and commercial fishing focusing on specific sites of interest. Finally, it aims to review any evidence of overfishing, its potential impacts, and how to address these problems in the future.

2.1 Subsistence Fishing

Fishing activity on Gau is primarily through subsistence fishing which is defined as ‘fishing for personal consumption or traditional/ceremonial purposes’ and provides the main source of protein for many of the local communities (Schumann and Macinko, 2007). Subsistence fishing is generally aimed at resources close to shore, whereas offshore fisheries typically require larger boats and more refined fishing equipment to target fish not part of the subsistence diet. Nearshore subsistence fishing has been the mainstay of Pacific Island

cultures for millennia but is now facing increasing threats from commercial and sport fishing industries (Maragos in Terry, 1998) leading to overfishing and depletion of resources.

Fishers used to rely on efficiency and knowledge to catch only what could be eaten or preserved over a short time frame (Maragos in Terry, 1998). This is still the case to a certain extent with many of the local women fishing on a daily basis to provide for their families. In the past large quantities of fish could not be stored and excess was given to others in the community in exchange for other foods or services and there was little incentive to catch any more than could be consumed (Pers. Comm. 2009). There is still limited power supply on the island with many families still relying on basic methods for cooking, lighting and heating. However, there have been some advances with increased travel to the mainland enabling deliveries of ice for the preservation of fresh fish. Discussions between Frontier staff and local villagers during workshops conducted in February 2009 provided evidence of increased fishing effort primarily for sales on Viti Levu. Many fishermen sell small bundles of fish to a middle man on the island who would subsequently transport them for sale at local markets. However, this does not appear to be an overly frequent happening.

A more recent cash economy and ability to catch and store larger quantities of fish has also lead to increased incentives for fishers to increase fishing pressure and deplete nearshore and coastal fisheries. Therefore, fish being caught and sold for local or offshore markets is starting to compete with subsistence needs of the local community. This in turn forces local fishers to increase their fishing effort with a move towards the cash economy with improved technology and equipment where traditional methods no longer suffice (Maragos in Terry, 1998). Although there appears to be no dramatic shifts in fishing effort yet and subsistence fishing remains the most dominant, there has been a gradual trend towards the cash economy on Gau.

The primary focus of the workshops and questionnaires, details of which can be found in Appendix 1, was to ascertain the frequency with which fishing took place, the type of method utilised, the species/families and size of fish caught. These workshops were held in the villages of Somosomo, Nawaikama, Nukuloa and Levuka. The full results of these can be found in Appendix 2 but Table 2 summarises the results of the workshops. However, many of the results showed quite contradictory responses from the villagers and were inconclusive. In general, most villagers partake in some form of fishing, be it alone, in groups, during the day or night, using various fishing methods. The methods vary considerably with the women mainly using hook and line, and nets, and the men using spears during the night. The location ranges from the fringing reef, usually fished by the women during the day, to the outer barrier reef, usually fished by the men. All of the fish in the catches are utilised, nothing is discarded or wasted. Although most of the fishing is primarily for their subsistence, within the last couple of years the villagers have started to export to the mainland due to increasing demand. Most of the villagers use a middle man from the village of Lovu who generally pays \$10 for three fish; this is then taken directly to the market in Suva.

Table 2: Summary of local fishing activities from 4 villages in the Sawaieke district of Gau.

Village	Fishing Method	Frequency	Location	Export
Levuka	Hook and Line Spear Gun Weighted Nets Boat	Most days	Inside lagoon, in front of village, on fringing and barrier reef	Large fish sold in Suva every 1 or 2 weeks via Lovu
Nawaikama	Hook and Line Spear Gun Nets Boat	Fish alone and in groups both night and day	Spears used on barrier reef. Women fish in surrounding bays	None
Nukuloa	Hook and Line Spear Gun Nets Boat	Women fish everyday Men spear fish 5 times a week	Fringing and barrier reef	Large fish sold in Suva via Lovu
Somosomo	Large nets boat and bamboo rafts	Fish every day both day and night	Shore fishing in local bays and on fringing reef	Large fish sold in Suva by Kali (local boat driver)

2.1.1 Fishing Method

Fishing technique is variable and dependent upon available human and material resources. Many of the village women fish along the shore usually catching reef fish. One popular technique called gleaning was experienced by Katherine Coussins, a BTEC student investigating the fishing activities of the local village of Somosomo. This fishing method focused on catching needle fish which are long slender fish that tend to swim close to the sea surface. It can be labour intensive and requires several women to cast out the nets but can also be quite rewarding with good catches.

Another method used by the women involves hook and line often using hermit crabs for bait. To ensure best possible catch the women usually position themselves on the reef in amongst the fish at waist height standing for long periods with short fishing lines. The women would also partake in night fishing trips but these usually required the use of a boat or bamboo raft called a '*bilibili*'. Hook and line or hand line fishing is the most common fishing method utilised in Fiji (Ledua and Vuki, 1997)

Unfortunately, the introduction of fishing technology in some Pacific locations has had more of a social impact on village activity, rendering the traditional shore based fishing conducted

by women less important (Veitayaki, 1995). At the present, time women still fish regularly and although this is an important source of daily protein for them it still also remains a socially focused activity.

The men are responsible for much of the spear fishing around the island, often during the evenings. The lights from boats could often be seen within the lagoon until the early hours of the morning. Men were more successful at catching the large fish such as trevally and barracuda, and often such night trips were rewarded with even larger fish. More often a few men would fish together and sort the catch on land; some of this would be sold on.

Due to the advances in technology and an increasing welfare there are changes throughout Fiji's fisheries (Lovell et al, 2004; Sabetian and Foale, 2006). Geographical Positioning Systems, radar, echo-sounders, more powerful vessels and improved processing methods continue to enhance the ability of fishers to exploit more living resources more intensively (FAO, 1997). Although such advances are not common on Gau the use of small engine powered boats and spear guns now enable fishermen to catch larger fish on the barrier reef. This has extended their fishing range considerably. This might have a positive effect on fishing activities within the restricted fishing zones located in the vicinity of the villages. In the future this could encourage fishermen to adhere to these restrictions helping to reduce the impact of shore based fishing and its destructive nature. The disadvantages can be seen in the ability to increase fishing effort and therefore fishing yield with a stronger move towards the cash economy. However, a study conducted from 1982 to 2002 on the Fijian island of Ono-i-Lau to examine changes in subsistence fishing patterns and the quantity and composition of yield from the fishery, discovered more positive outcomes (Kuster et al, 2005). It was found that the transition from traditional outrigger canoes to outboard powered vessels caused a dramatic increase in catch rate. Contrary to expectations, this has resulted in a reduction of fishing effort, rather than an increase in fishing yield, as the fisheries remain governed by subsistence needs and population size (Kuster et al, 2005). Despite the constant requirement for fish, there have been no reports of destructive fishing being practiced by the local islanders of Gau with no evidence of using explosives or poisons.

2.1.2 Fish Catch

During a stay in the village of Somosomo during August 2009 the Frontier staff and volunteers were witness to the landing of an early morning catch. This type of event attracts the whole village with many of the men sorting fish into appropriate bundles based on value. The process is very quick and the catch is tightly packed in ice and held within two large chest freezer, which although have no power act as good insulation. Most of the village partake in sorting the catch, with most taking their own personal share.

Communications with various villages in November 2008, during an initial social study, indicated size or species of fish was irrelevant. This was observed in Somosomo during the processing of the fish catch. All the villagers questioned as part of the study stated that all the

catch was retained for consumption by the family; there was no by-catch, no wastage and only limited export to Suva or other villages. Only those fish considered too small were returned alive during fishing or retained for bait. Of those fish that are sent to Suva for market sales most were either Wahoo (largest of the Mackerels), Grouper, Snapper or more commercially viable fish.

It was quite difficult to gain an accurate idea of average catch size according to location, method and time of day; catch could be up to 100 fish varying in shape and size. Most reef fish are between 5cm and 15cm long but the barracuda and Wahoo can be up to 150cm. Most of the women fished at least 3 times a week, often fishing daily, depending on requirements and this was evident throughout all the villages visited. When asked the size of fish caught many would demonstrate the size as from their hand to their elbow.

It was also quite difficult to establish the exact species caught as one problem encountered whilst performing the questionnaires was the nomenclature used for the fish species. Many of the local people use traditional names which are difficult to translate and often only descriptions were used to establish the species or families caught. This issue is currently being addressed by two students from the University of the South Pacific who are studying traditional terms and names used on the island of Gau to ensure these customary names are not replaced by western or scientific names (Pers. Comm. 2009).

Other non-fish species caught included turtles, which are considered a delicacy and are often caught for celebrations. Along the stretch of coast between Nawaikama and Somosomo the local fishers had become familiar with a number of caves and resting places where the turtles are likely to be found, allowing them to hunt in specific locations for the primary objective of turtle fishing.

Sharks do not appear to be actively fished; most are opportunist catchings and not hugely regular, mainly because they require stronger fishing equipment. However, a landing is very beneficial to the villages as they are often shared between several families.

2.1.3 Fishing Location

As with all other aspects of the fishing on Gau, location varied considerably but was mainly dependent on transport. Much of the fishing conducted by the women was on the shore or fringing reef which could be easily accessed by foot. This tended to be in local bays or areas close to the villages. Where boats were available the fishers would venture further from the shore with many fishing on the outer barrier which is more productive for the larger catch sizes. There are an increasing number of fishers extending their fishing area to include that of the Nigali passage where large shoals of barracuda, snappers and trevally were known to congregate. Due to the distance from shore and fuel requirements this is not a regular occurrence, but it does provide the fishers with a good yield.

Most villagers claimed they did not fish within the No-Take Zones (NTZs) or restricted fishing zones, however, on several separate occasions fishing in these areas was witnessed by Frontier staff. On five occasions local fishermen were politely asked to refrain from fishing within the NTZs directly in front of Naviavia beach. Further discussions lead to open admission that during various events fishing in the NTZs was accepted by the village and included most festive or celebratory periods which are fairly frequent. The understanding of the NTZs is still questionable and although they are locally managed the level of enforcement appears to be quite poor.

As previously mentioned, improved technology and equipment has enabled further areas within the lagoonal system of Gau to be exploited. The replacement of canoes and *bilibili* rafts with fibre boats, outboard engines and spear-guns has extended fishing grounds to beyond the villages. Advanced electronic equipment further allows schools of fish to be tracked providing maximum return for minimum effort (Veitayaki, 1995). As yet the fishing activities of the western coast of Gau remain within limited localities due to lack of such advances.

2.1.4 Summary

Many of the local villagers remain sceptical about the presence of Frontier and the motives behind such workshops, still fearing they will be apprehended for fishing in 'tabu' areas. However, through reaffirming the strong relationship that has been built up over the last few years, the villagers have become more open, with increasing informal discussions, allowing Frontier to gain a better understanding of the current levels of fishing activity.

Although there is some form of cash return for their fishing efforts, most is retained. The exportation of local fish to Suva is still relatively small in terms of percentage of the overall catch, but still provides the families with some form of income. All the local families are required to provide financial support to the village for its upkeep; this includes maintenance work on the church, communal grounds and schools as well as the general maintenance of the village. Therefore, with limited income many families rely on the additional source of income from fishing activity.

There is still a significant amount of subsistence fishing taking place within the lagoon of the west coast of Gau. As yet, this appears to be sustainable with little advances on fishing technique and frequency. Fishing in general remains a large part of daily life with the children assisting from an early age; it is a large part of the community and remains highly social. The target species are mainly reef fish although there is evidence of turtle and shark fishing. Shrimp fishing does also take place in the village of Nawaikama owing to the presence of a fresh water river that runs through to the mangrove system. Fishing at this level seems sustainable but with growing cash economy comes increased fishing effort and more pressure on Gau's marine resources.

A study conducted on the reefs of Ono-i-Lau has provided evidence of a sustainable fishing yield over a 20 year period (Kuster et al, 2005). This is a very encouraging result and provides a useful reference point from which to compare other reef fisheries in the region. The findings of the study also support the argument that non-selective harvesting of finfish can minimise the probability of ecosystem shifts (Kuster et al, 2005).

A similar study was conducted in the Northern Province of New Caledonia (Southwest Pacific Ocean) during 1997 to 1998, allowing estimates of subsistence fishing production. The findings showed that the catch from subsistence fishing did not result in a significant change of the exploitation potential. As the catch composition of subsistence fishing differed significantly from commercial fishing, there was a higher proportion of species less vulnerable to exploitation. These results suggest that such fish consumption surveys could positively assist in the design of subsistence fisheries monitoring programmes (Labrosse *et al*, 2006).

2.2 Commercial and sport fishing

As far as the author is aware, there has been no scientific or socio-economic study of Gau Island which could help document the changes in commercial fishing activity within the lagoon and along its barrier reef system. Many of the reports have been anecdotal evidence and suspected sightings of larger fishing vessels not known to be of local origin. Other information has been passed to Frontier from dive operators who are equally concerned with increased fishing activity.

2.2.1 Fishing at Nigali

The Nigali passage is a natural break in the outer barrier reef of Gau directly to the east of the villages of Nukuloa and Levuka, providing an opening into the inner lagoon. The only other opening to the lagoon lies much further north by Sawaieke at the dive sites 'Jims Alley' and 'Antheas Avenue'. The main significance of the site lies in the returning of adult grey reef sharks to breed. The area was also once known for its abundant shoals of predatory fish further providing an ideal nursery ground for the sharks. Due to the distance to Nigali and its high dependence on the weather to safely reach the dive site, limited studies have been conducted by Frontier. However, reports from the Nai'a dive boat have stated that over the several years in which they have been operating fish populations have diminished significantly, consequently, fewer sharks are returning to breed.

The Nai'a aims to be a conservation oriented dive operation focusing on eco-tourism. Its efforts include ocean temperature monitoring at depth, Tonga humpback whale expeditions, coral reef monitoring, coral reef baseline surveys along with a primal ocean project in the

Phoenix Islands. Although Frontier has always shown a heavy interest in the activities of the Nigali passage the real concern was evoked after information was forwarded on to Frontier and highlighted the devastating impacts faced by the once spectacular dive site.

The Nai'a had reported drastic declines in predatory fish, where up to 10 years ago divers were unable to see the sea bed due to the density of such shoals; they can now only expect one or two shoals within the whole of the dive site. The dozen or so Malabar groupers had now been reduced to three regular residents who have become increasingly wary of divers. Many of these declines are thought to have occurred a few years ago as a result of spear fishers, many using SCUBA equipment. Communications with villagers from the east coast of Gau indicate there to be SCUBA equipment present on the island, including a compressor, which has been provided with the sole purpose of training and diving for sea cucumber harvesting (Pers. Comm. 2009). Whether this is being used for spear fishing is unknown.

To assist with this rising problem a scientific study on the fish and shark populations of Nigali was instigated. Records of shark and fish numbers were conducted during organised recreational dives for the research assistants. Frontier hopes the data will help validate the growing concerns on the depletion of fish populations and help assist in establishing Nigali as a significant site of environmental importance demanding some form of conservation. Gau has already designated several no-take fishing zones as part of its initiative to conserve its marine resources and this should ideally be extended to Nigali.

Table 3 shows the results of the preliminary survey conducted between April and June 2009. The results indicate that the number of Grey Reef Sharks observed between surveys appears to remain relatively consistent although the observation in June does show only 10 sharks compared with the 15-18 recorded in May. While counting the sharks it was also apparent that a number had distinctive scars and chunks of fin (dorsal and caudal) removed. It is unknown whether these markings were obtained during natural shark activity or may be attributed to fishing activity. However, there was a single shark with very distinct evidence of fishing activity. This particular grey reef shark had a rope/noose around its upper body with a trailing hook from its underside. This shark has been spotted on two occasions between April and June 2009. Although there still appears to be a good population of sharks in the passage they are increasingly affected by the actions of the spear fishers often with visual wounds, hooks or lines trailing. Records of large predatory fish shoals are consistent with comments from the Nai'a with one occasion resulting in a single estimated shoal of only 30-50 yellowtail Barracuda (Table 3).

Table 3: Abundance of Grey Reef sharks and predatory fish within the Nigali Passage with approximate sizes in brackets for each of the four dates of surveying.

<i>Species</i>	<i>Date</i>			
	<i>07/05/09</i>	<i>16/05/09</i>	<i>23/05/09</i>	<i>06/06/09</i>
Grey Reef Sharks (adults) (5-7ft)	15	18 (2 pregnant)	19	10
Grey Reef Sharks (Juveniles) (1.5-3ft)	2	2	2	6

White Tip Reef Sharks (4-6ft)	6	4	1	4
Yellowtail Barracuda (80cm)	50	50	30	
Great Barracuda (120cm)	15			
Blackfin Barracuda (80cm)		30		
Spanish Mackerel (50cm)	100		100 & 500	300
Red Snapper (40-50cm)	50	3	30	
Malabar Grouper (2-4ft)	3	6	3	
Wahoo (4ft)				1
Trevally (2ft)		10		
Manta Ray		2		
Spotted Eagle Ray			1	
Turtle	1			

The World Conservation Union Global Shark Assessment have documented a large number of local, regional and global declines and near extinctions of oceanic and coastal sharks and rays with the assessment showing at least 32% are currently threatened with extinction (Camhi *et al*, 2007 and Field *et al* , 2009) . The main problem is how to halt such declines as many are caught unintentionally whilst targeting more abundant fish and there are currently limited restrictions on shark fishing. Also due to declining fish populations Nigali will lack its appeal as a breeding ground for the grey reef sharks and the area is likely to experience some form of trophic cascade due to the indirect effects of predator removal (Hall, 1999 and Dulvy *et al*, 2004). This is a problem being faced in a number of reef habitats in the Pacific with well documented declines in shark populations due to overexploitation (Robbins et al, 2006).

The solution, therefore, requires a balance between both conservation needs and sustainable fishing practices. One approach is to create Marine Protection Areas (MPAs). Such attempts at conserving natural populations of reef sharks have taken place on Australia's Great Barrier Reef through spatial management of a series of four restrictions zones of varying levels. The zones are: no entry, no take, limited fishing and open access ranked in order of fishing pressure (Dulvy, 2006).

Some of the local people are aware of the issues facing Nigali and its fish and shark population and agree that the idea of an MPA sounds beneficial. However, there is one overriding problem: many of the NTZ restrictions are already not being adhered to and these are well within a manageable distance of the villages. Nigali is a few kilometres from the land and reaching it requires access to outboard engine powered boats and substantial quantities of fuel. Unless a designated warden can be appointed to the area any regulations over fishing activity are likely to be disregarded.

Although Nigali is primarily a conservation and fishing issue that desperately needs to be addressed, it also is a secondary concern for the local villagers. Both the Nai'a and Aggressor diver operators partake in village visits where the local people perform the traditional and popular 'meke' a friendly dance by the men, women and children of the villages. The visit also encourages tourists to buy local handmade products. The decline in the appeal of Nigali

as a dive attraction could cause the dive operators to cease paying dive rights and not return to the area, having a potential impact on the village income. In addition, without the regular visits of the dive operator there will be no reports documented on any continued decline.

2.2.2 Other Commercial Activity

Although much of the evidence of additional commercial fishing in the lagoon is rather anecdotal, various vessels have been spotted travelling along the barrier for extended periods of time. It is suspected that these may be commercial fishing vessels. There is no evidence of this yet, but given the recent declines in shark and fish populations at Nigali it is highly plausible that much of these marine resources are being exploited by external fishermen. Some vessels have been sighted closer to shore but it is also unclear whether these are fishing or cargo vessels.

Sport fishing is also known to reduce available stocks for subsistence fishing due to the number of restricted fishing zones. There are currently no reported issues of sport fishing within the lagoon of Gau Island. Due to the lack of facilities for tourists, there are currently very few visitors to the island including sport fishers.

3. Impacts and Evidence of overfishing

During discussions with the local villagers the topic of overfishing or overexploitation of marine resources was never really broached and there were no indication of decline in fishing yield or concern over the longevity of the fish population. Certain study areas showed distinctly higher levels of fish numbers than other more productive areas, but in most instances this could be attributed to the natural habitat and substrate.

Although most of the emphasis with regards to overfishing is placed on commercial vessels, traditional subsistence fishing practices can also destroy the coral reef. Many of the fishing methods practiced can be highly destructive particularly those used within the coastal margins (Veitayaki, 1995). Within these areas exploitation may be more difficult to recognise due to the continued exploitation of such marine resources for a number of years at unknown intensities (Hall, 1999). One of the most obvious direct effects is trampling. The women spend much of their time walking over the reefs to access the most desirable fishing locations and for bait collection, causing damage to the underlying reef system. Habitat diversity and complexity is one of the major keys to a healthy and productive reef with regards to fish populations. However, this cannot be solely attributed to fishing activities, as any interest in the marine life of the fringing reef is likely to impact the immediate habitat (Lovell *et al*, 2004). In addition, many of the local boats are moored up using temporary anchors, each time destroying another head of coral.

Increased fishing activity can also promote outbreaks of coral eating starfish, the Crown of Thorns, *Acanthaster planci*, which is normally eaten by fish and other invertebrates. This can upset the equilibrium of the coral reefs and lead to a cascading effect whereby corals are replaced, possibly on a permanent level, by algae (Sweatman, 2008, Goldberg & Wilkinson, 2004 and Dulvy *et al*, 2004). However, during the year (2008-2009) there were limited recordings and sightings of the crown of thorns, which is a positive sign for the island.

Another early regional indicator of overfishing of nearshore resources has been the steep depletion of giant clams, trochus, pearlshell, sea cucumbers, sea turtles and sharks. These species are all large and conspicuous and have a high cultural and/or economic value. Unfortunately, they are also of high exporting interest to Asian and American markets, further degrading nearshore ecosystems (Maragos in Terry 1998). Without historical records of past population levels it is hard to speculate as to whether such species have sustained such a significant impact. There are still known sites beyond free-diving depths where giant clams still live in abundance. Other more accessible and shallow areas of the reef show distinctly limited populations of giant clams. Observations of turtles and sharks were sporadic and would generally not be classed as common, except for the population of sharks at Nigali.

The most noticeable effects of over fishing are shifts in species domination. Many fish species are natural predators, therefore in their absence invertebrates population size may increase due to lack of predation (Dulvy *et al*, 2004). One theory suggests that organisms at varying levels of the food chain alternate between being food limited and predator limited cascading through the trophic levels. McQueen *et al* (1992) and Carpenter *et al* (1985) produced a trophic cascade model predicting that by their presence or absence, higher trophic levels will determine whether or not large abundance of plant biomass will occur at the base of the system (Figure 1 adapted from Hall, 1999).

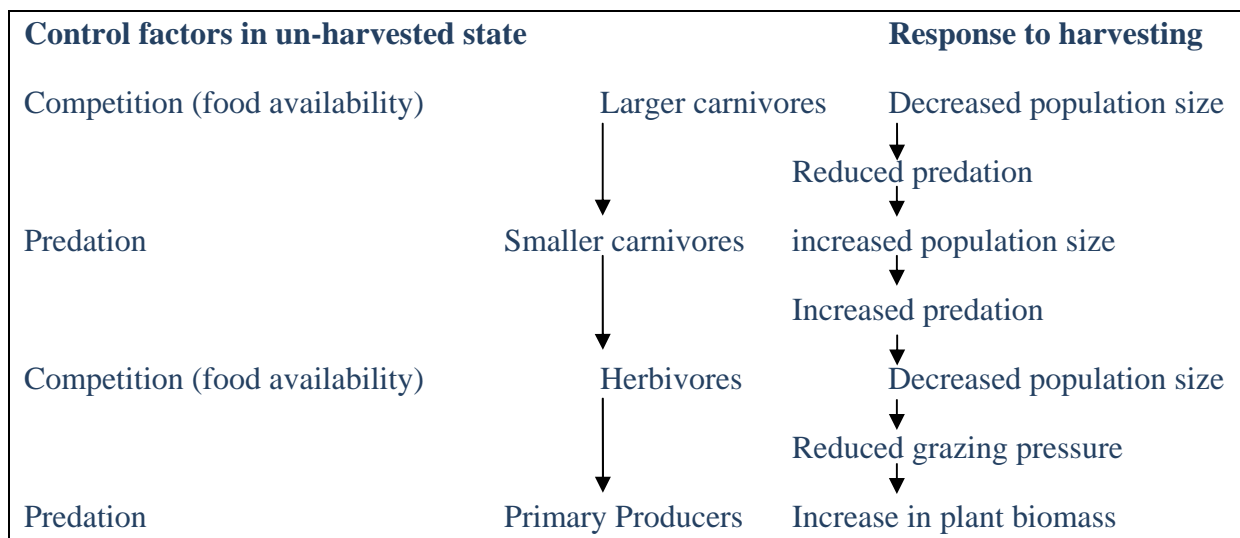


Figure 1: The trophic cascade model for a 4-level system with harvesting at the top level.

Given the predictive model above, one of the key biological factors to monitor within fishing areas is the biomass and coverage of algae or vegetation.

The general feeling on the island is that subsistence fishing is still producing sustainable yields and that the fishing effort has not changed considerably. However, there is no scientific evidence to validate such assumption. It is likely that those areas within close proximity to civilisation are more likely to be impacted than more remote areas. This has been observed on other Fijian islands. A study of the pristine great astrolabe lagoon showed that reefs that were relatively inaccessible to the local villagers were found to be in a healthier state than those in proximity to the islands (Morrison and Naqasima, 1999).

4. Addressing Fishing Impacts

There are two necessary steps to addressing the issues faced by increased fishing pressure: scientific studies to provide further evidence of changes in fish communities, and the subsequent establishment of appropriate management strategies based on the data collected. Several areas have been studied with regards to the success of newly established management programs. Some appear to have a beneficial impact on the health of reef ecosystems and sustainability of fish populations and general fishing activity. However, most have also highlighted the need for conducting long term monitoring practices to quantitatively assess biodiversity changes and attribute such changes to naturally or anthropogenically induced impacts.

4.1 Scientific Studies - Monitoring

It is widely known that the more detailed and long term the data is the better the chance of providing a tailored management plan to oversee the continued sustainability of the fishing activities. Policy makers need a scientific basis for deciding whether they should respond to social, economic and political demands for instituting or preventing ecosystem-based management (Jennings and Kaiser, 1998). Scientific evidence forms the basis of most management plans and provides a platform from which to develop them taking into account the specifics of the area. Frontier has been able to facilitate this process with its current monitoring program on the island of Gau (Grover et al, 2008). Despite the use of non-specialist volunteers, the data is able to provide a basic but accurate assessment of the current health of a reef (Darwall and Dulvy, 1996). However, as fishing activity has been a major part of the community for many years and monitoring has only recently been established within this area any changes in fish population due to fishing is unlikely to be detectable in the

results. So some caution must be placed on the weight of such data aimed at characterising the current state of artisanal fishing.

The initiation of fishing in an un-fished system leads to dramatic changes in fish community structure but as fishing intensity increases additional effects are more difficult to detect (Kuster, 2005). Therefore, in places such as Gau where fishing has been a key activity of the community for several generations it may be more difficult to monitor the long term impacts unless fishing effort dramatically increases. It may be more appropriate to study target species and the impact of their potential decline on the coral reefs and other fish populations. Monitoring such aspects of the reef such as benthic complexity and coral health will also provide a good insight into the health of the fish population. This is something that Frontier already considers so may be of high value in these situations where historic data is lacking.

A study by Jennings and Kaiser (1998) looked at changes in fish populations through both environmental impacts as well as fishing. Fishers tend to target species in sequence as a fishery develops leading to changes in the composition of the fished communities with time. However, the dramatic and apparently compensatory shifts in the biomass of different species in many fished ecosystems have often been driven by environmental change rather than the indirect effects of fishing. Indeed, in most pelagic systems, species replacements would have occurred, albeit less rapidly, in the absence of fishing pressure. Although fishing has reduced populations of predatory fishes these reductions do not have a consistent effect on the abundance and diversity of their prey: environmental processes control prey populations in some systems, whereas top-down processes are more important in others. New research is needed to guide managers with further stress on the importance of un-fished control sites for studies of fishing effects (Jennings and Kaiser, 1998).

Further studies on the effects of Marine Protection Areas also highlight the need for long term monitoring programs. Marine Protected Areas (MPAs) are known to enhance diversity, density and biomass of coral reef fishes and to modify the size and trophic structures of these fish assemblages (Ticco, 1995). Kulbicki et al (2007) compared the evolution of the fish assemblages of two adjacent reef zones, both initially MPAs, one of which was later reopened to fishing. The study demonstrated that on a short-term basis (2 years), natural variations can be of larger magnitude than changes that may be induced by management options, especially when fishing pressure is not very high. This makes it very difficult to accurately attribute fish population declines to fishing activity rather than natural changes. This is something that needs to be accounted for when drawing conclusions about the general health of the reefs and impacts of artisanal fishing.

Despite the importance of the inshore fin fish resources to the Fijian people, there is no systematic monitoring system to determine early signs of overfishing (Ledua and Vuki, 1997). A greater understanding of the state and trends of coral reef fisheries is required for the effective management plan for inshore fisheries. Despite numerous studies (Kuster et al, 2005, Lebrosse, 2006), the current state of reef associated fisheries at a national level is still uncertain due mainly to the lack of dependable data on subsistence fisheries, which leads to uncertainty as to how the continued fishing of target species for the coral reef resources trade

is affecting fishing communities and the ecosystem (Teh et al, 2009). Increased emphasis needs to be placed on the overall importance of scientific research with increased support in this area from local government. (Options for improving the science project are given below in section 10).

4.2 Management of fishing areas

As previously discussed, fishing impacts in coral reef areas, when ecologically unsustainable, can lead to the depletion of key functional fish species in many locations, with cascading impacts on coral reef ecosystems (McQueen *et al*, 1992 and Carpenter *et al*, 1985).

Specific impacts of fishing on reefs generally include one or more of the following:

- Direct overexploitation of fish, invertebrates, and algae for food and the aquarium trade;
- Removal of a species or group of species impacting multiple trophic levels;
- Bycatch and mortality of non-target species; and
- Physical impacts to reef environments associated with fishing techniques, fishing gear, and anchoring of fishing vessels

Appropriate management actions can reverse these impacts. For instance, ‘no-take’ areas in the Florida Keys and marine preserves in Guam have resulted in increased numbers and size of economically and ecologically important reef fish. Management actions focused on key coral reef species, such as the fish replenishment areas in west Hawaii, have also demonstrated success in protecting stock and maintaining the fishery for the important aquarium trade species (Jennings and Kaiser, 1998). Minimizing negative fishing impacts throughout coral reef ecosystems is critical to revitalizing and protecting coral reef resources for current and future generations.

A number of actions have been taken in order to improve the local understanding and awareness of the impacts of increased marine activity and overexploitation of fish resources. One such method was the use of the Locally Managed Marine Areas (LMMA). LMMA is an area of nearshore waters being actively managed by local communities or resource-owning groups, or being collaboratively managed by resident communities with local government and or partner organisations (Govan *et al*, 2008). It offers an alternative and complementary approach to the centrally managed system where a centralised body largely commands and controls the management of a marine area. LMMA differs from an MPA as they are characterised by local ownership and control whereas MPA are typically designated by levels of management via a top down approach, however, an LMMA may employ MPA or other management techniques. Two main constant aspects of an LMMA are the use of a well

defined or designated area and the substantial involvement of communities and/or local governments in decision making and implementation (LMMAN, 2005).

When implemented effectively, an LMMA has the potential to give marine resources the chance to recover from fishing and other pressures. The main benefits that stakeholders gain as a result of using this approach include:

- Improved habitat quality
- Increased fish population, reproduction and biomass
- Enhanced local capacity to manage their resources
- Increased environmental stewardship and community cohesion
- Increased income from marine resources

The Fiji locally managed marine areas network was first introduced to Gau on the east coast of the island within the Vanuaso Tikini (district) to help demonstrate the importance of human factors in fishery development and regulatory processes (Veitayaki et al, 2005). The concept was further tailored to the people of Gau and a new project was developed called the Lomani Gau initiative. This initiative is part of the continuing work to promote resource management in coastal communities that are modernising and utilising their natural resources. Resource management activities undertaken in the island have now been extended to include adoption of an integrated approach (Veitayaki and Murai, 2005).

The district embraced changes in how to better exploit environmental resources and worked to improve their lives and ensure the protection of their environmental resources into the future. Due to its success the concept was promoted to the remaining two Takinis on Gau thereby involving the Sawaieke district in which Frontier is based. The network is aimed at offering useful lessons to the quest for effective community based resource management working in collaboration with the University of the South Pacific and the International Ocean Institute-Pacific. Reports indicate the local people of the Vanuaso district have undertaken community-based development activities and are rehabilitating their coastal habitats based on the management plans that the people formulated during Participatory Learning and Action workshops (Veitayaki, 2008). The local people are also looking for alternative sources of livelihood (Veitayaki et al, 2006).

Despite the documented success of the Lomani Gau Initiative on the east coast of Gau there has been limited evidence of its presence within the Sawaieke district. Much of this is well documented within a study conducted by Frontier (Keely et al, 2010) which highlighted some of the key factors currently under discussion. Many of the issues drawn up as part of the Lomani Gau Initiative, such as housing of pigs, improvement of waste facilities and planting of vegetation, show little evidence that they have been acted upon. During the conducted workshops a presentation was provided to draw attention to some of the key points of the initiative and to instigate further discussion with the local villagers.

In some villages there was a distinct lack of understanding of the objectives drawn up as part of the initiative. One of the main problems appeared to be the lack of information dissemination. Many of the local people do not have the resources or finances to attend the

committee meetings that tend to be held on the east coast of the Island and are therefore not always privy to discussions. This is something that desperately needs to be addressed and an area in which Frontier can assist as a mediator between the meeting and local village committees. Frontier-Fiji has the means and resources to work alongside the Lomani Gau Committee and has the ability to take a more prominent role.

The key points of the initiative were discussed fully during the workshops and definitely helped raise an interest from the local attendees. One of the main points considered during the workshops was the establishment of NTZs as part of the process to ensure sustainable fishing activity. All the local people are fully aware of the restrictions of the NTZs but many lacked knowledge of the rationale behind them. There was clear evidence that there was an element of selectivity when it came to the adherence of such restrictions and there was an obvious need for improved knowledge of the current conservation issues faced by the villages. There is already evidence from other investigations that such systems do work. A study by Ashworth et al (2003) of the effects of reef top gathering and fishing activity on invertebrate abundance across take and no take zones lead to significant difference in population sizes. The NTZs showed a dramatic increase in invertebrate number since the restrictions were imposed. This information desperately needs to be conveyed via further educational workshops to the local villagers.

The workshops provide a great forum with which to mix ideas and cultures with the villages and help them understand the importance of the work being conducted by Frontier. They genuinely appeared grateful for the contact and our ability to translate some of the objectives set up for each of the villages. It was a very worthy process but is one that needs to be maintained on a more regular basis.

4.2.1 Summary

At the moment, the people of Gau Island are predominantly involved in subsistence activities but are increasingly transiting to commercial agriculture, intensive fishing and the alteration of coastal habitats such as mangrove forests and seagrass beds. In addition, changes in the villages caused by increasing population and westernised lifestyles are resulting in coastal pollution and more exploitative uses of natural resources that threaten people's living conditions. The Lomani Gau Initiative allows the villagers to make plans and decisions that are related to their social and economic requirements and yet are holistic in their outlook and consistent with known sustainable development practices.

Although very promising in theory the Lomani Gau initiative is not yet completely effective and still has much to do before it becomes fully integrated into the everyday lives of the local people. This is an important area of development for the future of Frontier-Fiji one that can benefit the whole island. Due to its lack of tourism, limited population and pristine barrier reef Gau should be considered in priority for long term protection.

4.3 Establishing Aquaculture and Mariculture Systems

An alternative to addressing the high levels of fishing pressure and subsequent impacts is the consideration of aquaculture or mariculture systems as a means of supporting local income with minimal impact on the natural marine resources. Mariculture has been known to be promoted in some reef and lagoon areas as an alternative to excessive harvesting and consumption of wild stocks (Terry in Maragos, 1995).

Aquaculture is the farming of freshwater and saltwater organisms such as finfish, molluscs, crustaceans and aquatic plants involving the cultivation of aquatic populations under controlled conditions (Pickering and Forbes, 2002). Mariculture is a specialised branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater (Phillips, 2009).

Aquaculture in Fiji has not been developed on a large scale (Jansen et al, 1990). Examples of current attempts include a Fijian prawn farm which aimed to produce 25 tonnes of Penaeidae in 1990, but did not even make it to the halfway mark in their goal (Veitayaki, 1995). However it has progressed substantially since the 1970's and now leads the Pacific island developing countries in terms of aquaculture development and diversification (Pickering and Forbes, 2002). Most aquaculture attempts in Fiji have aimed to cultivate high-value species for commercial exportation; however the country has not been able to compete with the aquaculture industry already developed in the rest of Southeast Asia (Watling and Chape, 1992).

Freshwater prawn aquaculture, though relatively new to the Pacific, has been identified as having great potential for countries in the region. This is something that is currently under study by Dr Chris Barlow of the Queensland University of technology, Australia (Barlow, unpublished data). If successful, it is plausible that Frontier may be able to introduce this concept to the village of Nawaikama where shrimp fishing is common.

So far the development of aquaculture in Fiji has been limited by lack of experience, expertise and suitable technology. But to date this venture has included the production of shrimp, tilapia, giant clams and pearl shell (Pickering and Forbes, 2002). There have been talks of introducing the cultivation of Giant clam beds with juveniles supplied by the local Fijian government but as yet sufficient funds have ceased to move this proposal forward. However, this is an area that still requires extensive research and discussion with the local communities of Gau.

Promoting aquaculture practices can aid with stock enhancement as well as reducing the effort exerted on the already heavily fished resources. Reef re-stocking has been proven successful in some parts of the world. Aquaculture could be one of the possible means of

reducing the pressure on the already overfished inshore resources of Fiji (Ledua and Vuki, 1997 and Veitayaki, 1995).

Although a good alternative to wild fishing aquaculture does have its draw backs. These methods usually target the more commercial species and can have significant impacts on nearshore marine ecosystems such as displacement of natural habitats, introduction of alien species and subsequent inbreeding with shifts in gene pool, introduction of effluent and removal of natural habitats to make way for specialised ponds (Pickering and Forbes, 2002 & Maragos in Terry, 1998). Therefore such projects cannot be considered lightly, they need to be fully understood and respected for all their potential effects. But it is definitely something to consider in the future for Gau's marine resources.

5. Agricultural activities

Frontier is not heavily involved in the monitoring of agricultural practices. However they are of high importance in the subsistence lifestyle of the Fijians. All of the community is involved in some form of farming and it is an extremely important means of food production and livelihood for local villagers (Pers. Comm. 2009). This was another issue that was discussed during the workshops.

All of the villages are surrounded by farm land; much of this is behind the village on the hill slopes. Although farming can occur on both flat and sloping land the hill slopes provide a better location offering adequate drainage during the wet season and allowing trenches to be dug to steer excess rainwater away from the crops. Flat areas of land are less productive for crop growth due to saturation of the soil during rainy times and lack of drainage ability. Many of the villages have limited flattened areas of land by the shore and rely solely on the hill slopes for farming. The soil close to the shore provides insufficient nutrients and crops are often attacked by the land crabs.

A variety of crops are grown within the villages including kasava and taro which are quite similar and generally the most frequently eaten vegetable comparable to a very starchy potato. Other fruit and vegetables commonly grown are yams, bananas, papaya, bread fruit, chilli, cucumber, Kava (ground up to make the traditional drink), sugarcane, mango and pineapple. There are no designated areas for fruit, trees are distributed throughout the village with individual ownership but are usually shared. Most villages produce more than enough crops for their own consumption and excess is exported to Suva and sold on the local markets using a 'middle man'.

Most families own an area of land and they are cultivated manually using limited tools and technology. It is the men in the village that are primarily responsible for the upkeep of the farm land and this accounts for most of their daily activity. The land is generally cleared by weeding the area, drying, control burning and ploughing. This is a significant problem in Fiji as the removal of established plants can cause much of the top soil to flush away during the

wet season draining directly into the sea. The conversion of land to agriculture with increasing soil erosion causes problems of sediment delivery with increased turbidity and settlement of suspended solids over the reef system smothering much of the coral and plant life and restricting light penetration essential for photosynthesis (Burke and Maiden, 2004). One problem encountered recently involved out of control fires that encroached on the land directly above the Nukuyaweni resort development. Apart from the obvious hazards attached with this and the impacts on the reef, it is also very unsightly and can destroy vast areas of land and vegetation. Therefore, alternative methods or land clearance need to be introduced.

Many of the villages use pesticides spraying the crops regularly due to problems of insect infestations. Fertiliser is sometimes used as well as pesticides both of which can increase the amount of nutrients in the water through run-off leading to algal blooms (Burke and Maiden, 2004). To overcome the problem of nutrient depletion in the soil, a shifting method of cultivation is in place, which varies from three year to five year rotations. Unfortunately there is no current composting system which could utilise waste produce which could result in a more sustainable system.

The crops experience rapidly changing environmental conditions which significantly affect the success of the harvest. Heavy rains destroy the crops very quickly whereby they become over saturated, followed by times of complete drought. Therefore different crops are grown and harvested throughout the year to ensure a year round yield.

In their current state the farms are able to produce sufficient crops for the full year: however, one area of concern was that of the reduction in the number of hill slope farms. This could be a problem for those villages where no additional flat land exists and has become one of the objectives of the Lomani Gau Initiative. This is already an apparent problem in the village of Nukuloa where there is little opportunity for village expansion due to the rapidly encroaching shoreline and presence of hills directly behind the village.

The most significant impact caused by farming is the clearance of land dense in vegetation which traps top soil and nutrients on the hill side. Deforestation and poorly regulated agriculture release excess sediments and nutrients (Goldberg and Wilkinson, 2004) having devastating effects for the reef system during period of heavy rain as previously described but could also cause mud slides that could potentially intrude on the villages as seen in some of the South American villages where excessive logging takes place. This currently doesn't pose much of a problem but it is worth highlighting for the future.

6. Tourism

Fiji is a popular tourist destination and its small and fragile nature renders it vulnerable to ecosystem damage. The most serious threats of tourism on coastal ecosystems include: location of hotels in close proximity to sandy beaches, resulting in shoreline erosion, sewage and rubbish pollution, selective overfishing of desired species, excessive aquarium fish

collection, overuse of reef areas by divers and snorkelers, anchor damage from tour boats; and loss of habitats including mangroves and beaches (Gormsen, 1997, Burke and Maidens, 2004). Unplanned tourism can have social, economic and cultural impacts causing major stress on the surrounding environment (Terry, 1998, Lovell et al, 2004). However, small scale tourism such as ecotourism is theoretically compatible with natural and cultural resources conservation but must still be planned, designed and sited carefully.

There are currently no resorts on Gau. The bay directly to the north of Naviavia beach is Nukuyaweni which is currently in partial development. The planned resort is based on eco-friendly concepts to reduce sewage pollution and limit human impact on the surrounding reef. It is also currently supporting the local economy with employment solely by locals from the surrounding villages of Somosomo, Sawaieke and Nawaikama. As the resort is not yet open, its future impacts are currently unknown.

The location of Gau and its restricted transport means that there is currently no existing tourism with Naviavia providing the only significant area of non native inhabitants. The closure of the airport/ landing strip and irregular trips made by various local shipping groups ensures that this island remains, at present, relatively unspoilt by tourism.

7. Natural Changes

Although global changes affect all areas, small islands are particularly susceptible to such changes. Many Pacific Island Countries experience natural disasters causing a lot of environmental damage and degradation including cyclones, floods, droughts and volcanic eruptions (Burke and Maiden, 2004 and Maragos in Terry, 1995). These have significant economic impact and it is often difficult for the countries to recover. Fiji is no different, experiencing serious drought in 1997 causing negative economic growth (Prasad, 2003).

Sea level rises are already impacting some of Fiji's smaller islands and Gau is no exception. Most of the villages have little or no defences from coastal erosion and where they do exist many are in a state of disrepair and unable to withstand the harsh battering of the waves during the regular cyclones experienced over the last couple of years. Many of the local people are showing concern over the changes in sea level and discussed the possibilities of land reclamation to help with recent flooding issues.

Unfortunately, many of the mangrove systems that used to exist around the island have been removed for development due to lack of understanding of their importance. Some of the villages still have limited areas of mangrove growth either side of the village but none protects the main village front. The village of Nukuloa has already expressed interest in receiving assistance from Frontier to help replant some of the mangrove systems in an attempt to prevent coastal erosion. The mangroves help to trap sediment and can act as a natural sea defence (Bos et al, 2007). This is a project that would be gratefully received by the local people and is very much a community based project that could strengthen the

relationship between Frontier and the local villages. It is something that should be considered throughout all the villages and is an area where Frontiers' knowledge could greatly benefit the local villages.

Additionally, natural disturbance such as heavy storms can have a devastating impact on the reef, tearing up many of the coral heads that take several years to recover. This was witnessed after the cyclones in January 2009 where there was significant damage to the house reef in front of Naviavia beach and many of the other sites visited for recreational dives. One of the main indicators of the heavy rainfall experienced was the forming of a river directly behind the camp. This flooded several areas of camp and caused a divide in the living quarters where the water flushed out to the sea. The large area of beach crossed by the river also got flushed into the shallow waters covering much of the seagrass beds. The shifting sand did not fully return to its previous location so not only is this contributing to the coastal erosion but it is also causing a decline in the seagrass beds which are known to be highly sensitive and important as indicators of good health.

Fishing also has significant direct and indirect effects on habitat, and on the diversity, structure and productivity of benthic communities. These effects are most readily identified and last longest in those areas that experience infrequent natural disturbance. Fishing has accelerated and magnified natural declines in the abundance of many forage fishes and this has led to reduced reproductive success (Jennings and Kaiser, 1998).

8. Addressing impacts from land-based pollution

The suite of problems facing coral reef ecosystems from land based sources of pollution is broad and includes sediment, nutrients and other pollutants, originating from a variety of land based activities that are transported in surface waters, run-off, groundwater seepage and atmospheric deposition into coastal waters. These pollutants can cause disease and death of sensitive coral species disrupt critical ecosystems functions, cause changes in the structure and dynamics of the food chain, and impede coral growth, reproduction, and settlement of coral larvae (Singh *et al*, 2009, Bolabola, 2007, Pastorok and Bilyard, 1985).

The coral reef conservation program of the National Oceanic and Atmospheric Administration and other coral conservation entities seek to control land based sources of pollution through collaborative approaches and a variety of funded projects (NOAA, 2007). Controlling land based sources through watershed management takes a concerted effort by all stakeholder parties including local, state, federal and non-governmental organizations. It requires planning, prioritising and implementing a multitude of best management practices throughout watersheds to achieve healthy water quality. Practices might include voluntary or regulatory activities on agricultural, public, private, urban or protected lands. Waste management through septic systems or waste water treatment plants, is also integral to water quality protection. Protection of significant portions of the natural watershed landscape,

through easements, trusts, or reserves, is the single most important aspect of managing the watershed for water quality and ultimately coral reef protection (NOAA, 2007).

Not much is known about the final destination of much of the waste produce of the villages. A full study was completed by one of the research assistants, Tom Tangye, as part of his BTEC project; this was conducted mainly in the village of Somosomo but also to a lesser degree in Nawaikama. His studies detailed much of the processes currently happening in the villages and their means of waste disposal.

Most of the houses within each of the villages have a private toilet. Most of what is known about their systems is that they drain directly into a holding tank and the waste is retained there until the system is full. From what Frontier could ascertain, once the tanks are full the contents are removed and disposed of directly into the sea. Some discussions gave the impression it was dumped into the sea from the headland of the village. Other information suggested it was placed in a much larger pit located in an adjacent bay. As the pits are located well behind the shore line there is limited leaching into the sea. By the time the waste has reach the reef it will have been well filtered with many of the nutrients already removed. This may not be an immediate threat to the coral reef system but it does have serious implications with regards to land use and sustainable waste disposal.

Other waste produce from packing and waste food is also placed in a larger pit. Once this pit is full another is dug by members of the village but each pit generally lasts a few years. Unfortunately, none of the food waste is retained within a compost system, this was rather surprising at it could prove to be very beneficial to their farming practices as fertiliser. This is an area in which Frontier can offer assistance and encourage the local people to store all their vegetable and general food waste in a general village compost.

Most villages rear pigs and these are usually held within pens along the shore line. In Nawaikama they are held within the mangrove system which is a problem as the pig waste will flush directly into the sea. The area of sea directly in front of the pig pens is highly turbid with thick layer of mud, which is likely to be a consequence of the farming activity. It is also very important to try and keep the areas of reef directly in front of the villages free from faecal waste as any of the children swim and wash in these areas and the village women regularly fish here. With increasing numbers of flushing toilet this may be a problem in the future and a management system needs to be developed to ensure faecal matter does not contaminate the washing or drinking water.

In general, most of the villages are very tidy, there is no litter and the village community regularly participates in cleaning up the communal areas. The current level of waste does not appear to be a problem but many of the flushing toilets are relatively new so it is yet to be seen how the waste disposal system works on a longer time scale. Appropriate waste disposal is something that needs to be fully broached and discussed within the remit of the LMMA and Lomani Gau Initiative.

9. Recommendations

There are a number of natural and anthropogenically induced problems being faced by the Island of Gau. Some may benefit from immediate remedial action; some require more delicate forms of management or steering, while other areas still require more data and information. The Island of Gau does mainly consist of natives, there are no regular transport links to the main land and most of the impacts are a direct result of the local activities. However, due to the difficulties in reaching the island there is often a lack of contact from organisations or authorities that can help steer the management programs and guide the local populations to manage their own resources more effectively.

Although Frontier has been present on Gau for almost 4 years, it is evident that its input has had limited effect. There is still a severe lack of understanding of the work carried out by Frontier despite regular communications with the surrounding villages. However, there are a number of ways in which this may be rectified so that Frontier can have a larger impact on the monitoring and conservation of the marine resources. Some examples are discussed below and include;

- Increased communication with locals
- Involvement in aquaculture projects
- Assisting with education
- Increasing communications with other organisations
- Improving and focusing scientific research

9.1 Communication with locals

The relationship between Frontier and the local people of Gau is generally quite good; however, it could be significantly improved. Often the villages are sceptical of our intentions and although they are happy to communicate, they are often reluctant to extend this to matters associated with conservation issues particularly fishing activity. Communication with the locals has to be more constant and Frontier needs to integrate better into the local community, more actively participating in conservation projects with direct benefits to the locals.

M of staff and volunteers have spent evenings in the village of Somosomo staying with separate families and enjoying being part of a very different culture. This definitely assisted with building trust and helped formed bonds between the local families and the volunteers. This further enabled Frontier to gain more information about their fishing and farming activities. Some volunteers were able to spend time partaking in some of their daily activities to the benefit of all. This is an event that needs to be incorporated into the regular schedule of

the work program. The women have been able to assist with cleaning the village and the men have helped to build kitchens and paint buildings.

The best way to show how much Frontier want to help sustain the traditional lifestyle of the local villagers is to become much more integrated into village life. There are a number of tasks that require commitment and a small task force to ensure they are accomplished, this is where Frontier should be assisting. Many of the mangrove systems have been destroyed and are now in desperate need of replanting. Some of the villages are facing rising sea levels and encroaching water levels are resulting in severe floods during the wet season. Frontier need to designate more time to community activities such as assisting with building sea defences.

There are a number of ways in which to earn increased trust and improve the current relationship between Frontier and the local people. Regular employment of locals increases good will and helps ensure the protection of camp as will more regular contact that doesn't just involve laundry and water collections. Such suggestions include;

- Employing a boat driver - many of the local men have much better control of the fibres and a much better understanding of how to drive the boats according to the weather and sea conditions. An alternative to regular employment which is not likely due to financial constraints would be to ask them to supply a course to the new members of staff on how to drive the boats and maintain the engines or temporarily fix them in the event of an emergency. Any general education on the running of the boats would be beneficial to the Frontier staff as well.
- Locals sit in on lectures - the locals would benefit from attending some of the initial lectures provided by the principal investigator on the objectives of the project and the outputs. They would also benefit from learning more about their marine environment and the interactions that take place. The lectures delivered generally start quite basically to accommodate the different levels of knowledge of the research assistants so would be generally understood by the locals.
- Offer some formal form of teaching to the local children - the children would probably welcome the opportunity to learn more about their environment and be taught the basic survey techniques. They could assist with some of the basic monitoring; this would help increase their levels of interest in conservation issues and enable them to possibly take on the monitoring program in the future. If the local people fully understand the reasoning behind the restricted fishing zones they are more likely to adhere to it.
- Regular night stays - this has proved to be highly rewarding for all the participating members of Frontier, as well as the local people. This allows for a much better appreciation of the different cultures and gives Frontier the opportunity to give back to the community by helping with some of the daily tasks.

- More regular trips to local villages and not just for water runs - quite often the only visits to the village are only for the benefit of Frontier. Such trips need to be combined with lecture sessions or providing some additional service.
- Volunteers help participate in fishing trips, this will help locals not to perceive frontier as a threat but as an asset. One research assistant participated in a fishing trip on the fringing reef outside of the local village. Although Frontiers' main objective is conservation of the marine resources, participating in the villagers' activities also aids to form a better understanding of the techniques used and the levels of impact.

There are probably a number of other ways in which the communication could be improved but the most positive means is to give something back to the community and provide evidence that Frontier is willing to help.

9.2 Aquaculture

The possibility of establishing some form of aquaculture system has already been partially discussed in section 5.3. There may be good opportunities for the villages to establish alternative means of income from aquaculture and to help make full use of all the marine resources. It may be possible for Frontier to work in conjunction with some of the local authorities to help set up such programs. Frontier could provide some of the hands on assistance that may be required on a more frequent basis.

There are a number of marine resources that are not yet being fully exploited by the villages, such as shellfish harvesting and aquaculture, but could be highly valuable to the cash economy of the island. This may help deter additional fishing for export.

9.3 Education

Frontier has been involved in teaching in the pre-school at Somosomo for one morning during the week. This mainly included game playing, basic spelling and English and reading to children between the ages of 2 and 5. The teaching hut was quite run down and with no regular teacher to maintain the area, it had become very messy. As part of one of the research assistants BTEC project, an attempt was made to improve the conditions of the school. This included decorating the space with banners of the alphabet and numbers, providing a proper reading area with seating and setting up a shelving system to store the books and toys. However, their teaching aids are still very limited and it was proposed by the RA's that new volunteers should be asked to bring old books and toys with them to give to the children. This suggestion could possibly be included in the volunteer hand book.

It may also benefit the locals and Frontier to provide lectures at the local high school. This has already been discussed in section 10.1. Most of the resistance from the local people to help achieve the objectives of Frontier is driven by their lack of knowledge. This is something that clearly needs to be addressed in future phases. It is essential that the school children of Gau are fully aware of Frontiers' aims and there clearly needs to be improved communication with this generation. Involving school children in the questionnaires and providing additional education for them is one of the next major steps that needs to be taken with this project.

9.4 *Communication with other organisations*

In order to help Gau proceed with the Lomani Gau and achieve all its objectives there needs to be greater involvement from other organisations. There needs to be an improvement in communication with other conservation organisations and the University of the South Pacific. This is mainly hindered due to the communication limitations whilst on the island. However, it is clear that these channels of communication need to either open up or be reaffirmed. The data collected by Frontier should be passed onto local organisations that may have a greater power in enforcing fishing restrictions or be able to act upon some of the findings. Working in collaboration with other organisations would also help bridge the gap between the local people of Gau and Frontier. Frontier could also become more actively involved with other projects which may result in improved recognition.

9.5 *Scientific research*

The scientific research to date has been highly valuable to provide an initial assessment of the fringing reef system and a baseline from which to develop the project. However it is important that the project expands into monitoring more varied environments and species. The following section puts forward a number of suggestions and recommendations for the improvement of the project.

9.5.1 *Baseline Survey Protocols*

It was suggested that during phase 094 the baseline surveys be reduced to include a single depth but increase the number of sites. The idea behind this was to get a better spatial comparison. Some of the sites that have been monitored over the last few years have not

necessarily been comparable with some consisting primarily of sedimentary substrate whilst others are significant areas of fringing reef. It is important to maintain a level of consistency between monitoring locations. One suggestion is to rotate the depths of sampling to gain data for both spatial and depth variability.

The baseline surveys from phases 084 to 093 consumed much of the daily activities and training requirements. By reducing the number of BSP's there is an increased opportunity to conduct more specific studies that may be of greater benefit to the general island community.

9.5.2 Restricted Fishing Zones

Frontier has never had accurate documentation of the boundaries of the no-take zones most of the areas have been described by the locals but with limited accuracy. These would prove highly valuable and would enable Frontier to conduct studies within fishing and non-fishing areas. This would provide further evidence as to the success of the restricted areas and would allow increase surveillance to ensure the restrictions are adhered to.

9.5.3 Workshops

It is evident that there is a lack of full understanding of the objectives of the Lomani Gau initiative. Frontier needs to hold regular workshops to assist with the communication with the local villages and help to explain and act upon the suggested improvements put forward for each village by the initiative. With increased communication between Frontier and the University of the South Pacific these workshops can provide an ideal means of promoting active participation from the local people. They also provide a great forum from which to discuss various issues and where the local people feel comfortable asking questions. This also helps decrease the gap between the villagers and Frontier.

9.5.4 Monitoring Nigali Passage

Although this had already been proposed in phase 091 and preliminary studies have taken place, this needs to become a fixed requirement of the monitoring project. As described in section 3.1 Nigali is already under pressure from over fishing which is threatening the future of the site as a grey reef shark breeding ground. The Nai'a dive operation conveyed their concerns of this to WWF Fiji. Frontier should actively seek to make contact with both the Nai'a and WWF and attempt to work in collaboration. This may also be a good opportunity to secure additional funding. With increased interest in this area there may be more chance of

it being designated as a NTZ or a Marine Protected Area enabling it to retain its appeal as a world renowned dive site.

9.5.5 Monitoring Target Species and Indicator Species

The monitoring of target or indicator species can help provide a better understanding of the changes or shifts in community composition. This could be achieved through specifically designed projects such as;

- Studies of sea cucumber or nudibranch size abundance and depth distribution;
- Detailed studies of the giant clam population peninsula between Naviavia and Nawaikama monitoring its growth;
- Detailed studies of fish indicator species such as the butterfly fish to enable more distinct trends in changes in the health status of the reefs to be revealed;
- Studies of frequently caught fish to monitor changes in population sizes;
- Further studies of species of potential economic value to the island such as shrimp which may have harvesting potential.

These are suggestion that may be easily incorporated into different phases and may provide a better insight to the health of the surrounding reefs and the current impacts of fishing activity.

9.5.6 Coral Bleaching

Coral bleaching is a good indicator of global climate change. Sudden increases in water temperature can have a devastating effect on the survival of coral species. This is something that could easily be included into the role of the benthic surveyor.

9.5.7 Socio-Economic Studies

There is definitely a requirement for more intensive socio-economic studies. These studies can serve three purposes; (i) to improve communication and interaction with the local people; (ii) allow Frontier to gain a better understanding of their culture and daily activities and (iii) provide more detailed information on the levels of fishing effort. Although Fiji Fisheries Division has good data on the volume of fish landed on various market outlets throughout Fiji, there is very little information on fish sizes caught, fishing effort, reefs where fish were

caught, catch per unit of effort and volume of fish caught for subsistence needs (Ledua and Vuki, 1997).

There are a number of ways in which more information about the fisheries can be obtained but the easiest way to incorporate it into the current work program is for Frontier to conduct regular questionnaires. Frontier regularly makes trips to the local villages for laundry, water, teaching or general visits. Each trip should be accompanied by a research assistant whose primary objective is to complete a questionnaire. There is also the suggestion of asking school children to participate for a week by asking their families to complete the questions each day thereby producing a story attached to the activities of the fishing trips (FOA, 2001). This would provide Frontier with extensive data for little output. The following questionnaires have been based on an example by Hosch (2000) and can be found in Appendix 4. They are easy to complete and would help in the monitoring of fishing activity on Gau.

10. Conclusion

As with many studies in remote tropical areas there is a lack of data to characterise the situation accurately. The best outcome is the production of a detailed account of the activities and use of marine resources that has taken place over a year from October 2008 to September 2009, including all personal observations. This can help address the major causes, changes and consequences in the way that humans have used and abused coastal resources and to focus on predicting the future patterns of development and population growth and identifying the interventions that will be necessary to insure the conservation of nearshore marine and coastal resources.

It is impossible to reach an overall conclusion as to the current state of the fish populations and impacts of human activity on the natural status of the reefs due to limited historic data. It is thought that in areas of Oceania, outside of urbanisation, such as Gau, coral reef systems are in good or excellent condition (Maragos in Terry, 1998). This was the general opinion of the status of Gau's fringing and barrier reef. However, with the reef system resources of urban centres such as those on the main island of Viti Levu declining, fishers are more likely to broaden their fishing zones to deplete healthy stocks elsewhere. Therefore, increased efforts should be made to ensure the current status of the reefs and fish populations of Gau is maintained and monitored for increased fishing activity and to enforce the no-take zones or 'tabu' areas.

The main benefits of Frontier are that it provides important data from which to base subsequent monitoring and data collections. However, to be more effective the information collected should be transferred to organisation, mainly local, who are able to process it and act on the results in order to ensure that the marine resources of Gau are sustainably exploited in the future.

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Appendix 1. Workshop details and questionnaire

A) Frontier Workshop presentation, Gau

Who is Frontier?

Frontier is a not-for-profit conservation research organisation based in the UK. Frontier was invited to the island of Gau in 2006 with the help of the University of the South Pacific and Joeli Veitayaki to compliment the work previously conducted on the Eastern side of Gau as part of the Lomani Gau Initiative.

Why are we here?

Our purpose on the island of Gau is to conduct research on the islands marine resources working in collaboration with the local communities, the University of the South Pacific and International Oceans Institute - Pacific Islands with the aim of providing valuable information to the local communities to assist with the conservation of the marine ecosystem and promote sustainable development in the use of marine resources.

What do we do here?

We consist of a core team of five members of staff (introductions) and we are all responsible for different aspects of the project. We currently have 3 volunteers. Despite being a UK based organisation we have staff and volunteers from a number of different countries and we all work together to achieve the same objectives. Our volunteers stay on Naviavia for between 4 and 20 weeks. As a team of staff and volunteers, it is our primary objective to survey the surrounding fringing coral reef system and research the current levels of fish, algae, invertebrates and coral species diversity and abundance. Frontier uses Naviavia as its base camp from which to conduct such research projects.

This program starts with training all volunteers to dive, making sure they are all fully competent in the water. This is followed by intensive training in the identification of fish, invertebrate, algae and hard coral species and all the techniques we use to study them. During this time they also become accustomed to camp life, learning to live without their usual basic luxuries such as an endless supply of water, electricity, gas cooker and comfortable beds. They all learn to cook on the open fire and become more aware of their surroundings and learning to appreciate the local culture particularly enjoying the Kava sessions.

Once they have fully integrated into camp life the core surveys start to take place. These are called the baseline survey protocols. These consist of two 20m stretches under the water that we swim along recording the total number and species of fish, algae, invertebrates and hard corals. The surveys are conducted at four different depths, 0-2m on the shallow reef flat, 2-4m on the reef crest. Because these two locations on the reef are still quite shallow we use snorkelling equipment. The remaining two depths are at 6-8m and 10-12m which required us to use scuba diving equipment. These surveys take places at fourteen sites located in front of Sawaieke, Somosomo, Nukuyaweni, Naviavia, Nawaikama, Nukuloa and Levuka. The program also includes studies of the seagrass beds, the presence of mangroves along the coast and water analysis looking at changes in the temperature and salinity.

What is the importance of the work we do?

Gau has become more and more involved and concerned with the use of its land and marine resources. This initiated locally run management methods that directly involved the local communities and were known as the Locally Managed Marine Areas (LMMA) this was first adopted on the east coast of Gau by the Vanuoso district and led to the establishment of five no take zones in the waters directly in front of the villages. This has since been extended to incorporate a combined effort with the formation of the Lomani Gau committee and resulted in each village in Gau designating a no take zone in front of their villages as part of a marine protection area. Frontier was invited in 2006 with the help of the University of the South Pacific to assist with this locally run initiative. This has the overall aim of assisting the local communities in the management of their environmental resources. This initiative has arisen due to the increasing village populations, commercial agriculture, intensive fishing, and alteration of coastal habitats such as mangroves and seagrass beds that are currently taking place. The biggest concern is the exploitation of the natural resources. Some of the issues now being addressed by Lomani Gau include:

1. The surveying of all communities and their resources
2. Proper use of the land use guidelines
3. Planting and managing coastal forests and special habitats
4. Protecting valuable coastal habitats
5. Reducing the uncontrolled cutting of trees, burning and farming on hill slopes
6. Protecting water catchments to avoid contamination of drinking water
7. Improving fishing areas
8. Establishing an appropriate level of fishing effort and increasing fisheries management activities
9. Setting up ecotourism operations

Unfortunately the current state of the fringing reef of Gau is relatively unknown. This information is important due to the links between reef health, fish stocks, local activities and land use. Part of Frontiers aims and objectives is to use our research capabilities and knowledge of the marine ecosystem to help extend the current environmental management

activities to encourage waste management, replanting of mangroves and control of fishing and livestock activities to help improve resource management and sustainability.

Diagram to explain the links between local activities and the management of natural resources.

1. Deforestation leading to soil erosion and land run off, lack of a root system to retain some of the nutrient rich top soil. This could directly affect the productivity of local farming activities and could reduce yield. Excess water run off could also become a problem during heavy rain-fall.
2. Increasing populations in the coastal villages, including livestock, will lead to increased waste production; this needs to be carefully managed to ensure water sources are not contaminated. Increased sewage waste into the open sea can cause a shift in the balance of algae and corals as the increased nutrient content of the water will encourage increasing growth of algae that will smother the hard corals and directly affect the productivity of fish populations.
3. Due to increased populations many of the mangrove systems have been removed, to use the land for other uses such as sea defences or additional land for building. Mangroves are valuable extensions of the reef system providing important habitats for juvenile fish and invertebrate without which many of the species are unable to survive in the open sea. The mangroves also help trap the suspended solids this is important for the adjacent seagrass beds which rely on very clear waters for their growth, these are also valuable nursery and feeding grounds for fish.
4. All these factors can affect the fringing reef by causing a shift in the dominant species, algae and sediment will smother the reef destroying the hard and soft corals that are essential for the fish and invertebrate communities. This will directly reduce the numbers and types of fish present. The overall results will be much smaller and much fewer fish present.

These points highlight the need for a well developed monitoring system to manage local activities including both land use and marine resources. The no take zones are important as they form the basis of a Marine Protection Area whereby resources extraction or human access are strictly regulated or prohibited. The establishment of no take zones are an important ecological factor in improving the health of the fringing reef system.

1. They can enhance stock size and yield of fish catches
 - An unaffected reef can produce up to 25 tons of fish per Km annually
 - An affected site will only produce 5 tons
2. No take zones can improve the general recruitment and enhance yields of the surroundings areas via the migration/movement of fish from the un-fished no take zone. This can also assist with the rehabilitation of over fished areas or damaged areas.
3. Help increase fish size as within the No take they will be able to grow to full adult size. If large fish are continually removed this will result in an overall decrease in fish size. Beqa lagoon as an example.

4. Encourages habitat protection and species preservation as an untouched habitat will be able to maintain a high level of species diversity providing a better environment for recruitment, growth and overall productivity.

Well managed MPA's have an ability to halt depleting fish stocks and help damaged reefs recover. The long term increase in fish yield, recruitment, size and species variability will compensate for the restricted fishing zones.

Frontier aim to help with this by providing information to help further developments towards a long running management program to ensure sustainability of the marine resources of Gau for several generations and hopefully extend current management schemes.

We aim to encourage water management programs, replanting of mangroves, preservation of seagrass beds and reef systems, management of land use and sea activities as a means of achieving the islands long term objectives.

What is the purpose of the workshop?

1. To introduce ourselves and open the channels of communication between the locals and Frontier.
2. To provide a forum from which Frontier can share our information including regular updates on the status of the seagrass, mangrove and coral reef health, including fish stocks, to locals and in return learn more about the local activities and culture.
3. To build relationships and work more closely with the locals in the development of resource management programs.
4. To instigate a possible teaching program in the local high schools about the reef system and its conservation issues.

B) Socio - Economic Questionnaire

General and social aspects

- Male/female
- Ages
- Daily Jobs
- How many people are living in the village and how many families?
- How many children are there under the age of 15?
- How many of the children attend school, primary and secondary?
- Is there a local school or do the children board in a different village, if so where and for how long?
- Is there a pre school in the village?

Fishing

- How many times a week do you fish?
- What is the average size and number of fish you catch?
- What species do you catch most frequently?
- What method of fishing do you use; boat fishing, net fishing, line fishing etc?
- Where do you fish, on the fringing reef, barrier reef or lagoon?
- Do you use retain all your catch or does some get exported to Suva?

Agriculture

- What type of crops do you grow?
- How often you harvest the crop and what is the average yield?
- How do you clear the area for crops, e.g. slash and burn?
- What do you do with the crops, sell locally, export, or consume within the village?
- What type of farming practices do you use?

Mangroves

- Do you have any existing mangroves (if not then were there previously existing mangroves present)?
- Do you harvest the mangroves is so what do you use them for?
- Has your generation removed any of the mangroves within the last 10 years?
- Is there a replanting management scheme in place?

Conservation and management issues

- Are you familiar with LMMA (locally managed marine areas) and the no take fishing zones in front of the village?
- Do you know where the boundaries are for the no take zones?
- How do you feel about the conservation of the reef and the work that Frontier is doing?

Appendix 2. Results from workshop discussions and questionnaires

A) Levuka

Socio-economic questionnaire Levuka

02-02-2009

List of attendees

Villagers Present	Age	Job
Waisea V	24	Farmer
Tevita R	27	Farmer
Tomasi V	52	Farmer
Saiasi R	40	Farmer
Rusi R	45	Farmer
Laishasa T	45	Farmer
Semi K	35	Farmer
Kail	37	Farmer
Vereti	24	Farmer
Eroni R	74	Farmer
Vilive K	70	Farmer
Naca D	24	Farmer
Lasarusa B	33	Farmer
Pawla C	52	Farmer
Fatum	39	Farmer
J Mua	34	P/ Master
Mereseini	35	Domestic duties
Litimai	39	Domestic duties

General

A discussion was held with various members of the village ascertaining various aspects of their daily activities. The village of Levuka currently consists of 124 people within 27 families. There are between 36 and 40 children (under the age of 15) residing in the village with 27 attending primary school at Nukuloa and 9 attending Nawaikama secondary school. There is a Kindergarten in Levuka open to those too young for primary school.

Fishing

The villagers fish alone and in groups using several methods; line, spear gun and weighted nets. They fish three times a week and take over a hundred fish each time. The women fish most days catching various species and sizes of fish most common being Kawakawa and Barracuda. Most used fishing lines with additional use of nets to catch shrimp for bait and this is conducted at various locations inside the lagoon including directly in front of the

village on the fringing reef with a weekly trip outside the barrier reef. Most of the fish is retained but some of the larger catch such as the Barracuda and Wahoo is exported to Suva once a week via a middle man from Lovu who sells them at the market. Most widely caught fish are Wahoo, Parrotfish, Ta, Trevally, Barracuda and Snapper. The villagers will fish in any area apart from the no take zone.

Agriculture

In Levuka all the villagers own an area of land growing mainly taro, kasava, yams dalo, kava, bananas, papaya, cucumber and chilli. The villagers feel they have more crops than they can eat. Some of the harvest is exported to Suva via the same middle man. Agricultural areas are cleared by wedging, cutting, drying and then burning. The farms are managed manually with additional use of crop spray due to problems of insect infestations. The crops experience rapidly changing environmental conditions which significantly affect the success of the harvest. Heavy rains destroy the crops very quickly this is exacerbated by the flat nature of the land although some of the farms are located on the hill slopes which provide better drainage.

Mangroves

Currently no mangroves exist around Levuka but there are some seagrass beds present. Villagers do not use the mangroves for any purposes and have not replanted any over the last ten years. There is also little stable seawall present with concerns of land erosion. This problem is being tackled through a mangrove replanting scheme to be conducted by the local youth group lead by Josepha Mua.

Conservation Issues

The Chairman of the Lomani Gau Initiative Seru is based in Levuka and first told the villagers about the no take zone last year at the last meeting. There was generally consensus that the no take zones present outside the village were a good idea although complete adherence to these restrictions was unclear. They believe the initiative is a good thing to have however meetings have not continued. They appeared to approve of the work that is being conducted by Frontier and were grateful for the communication.

B) Nukuloa

Socio-economic questionnaire Nukuloa

05-02-2009

General

The village of Nukuloa consists of 130 people of which 80 are adults. They are divided over five clans and 37 families. Of the thirty children and young adolescents 26 attend the primary school (age 6-13) in between Nukuloa and Levuka and 4 attend the secondary school in Nawaikama (age 14-17). At the moment there is no pre-school in Nukuloa due to a lack of teachers.

Fishing

The women of Nukuloa fish independently every day for subsistence purposes only. They use lines with hooks (90%) and nets (10%) from bamboo rafts called bilibili's, primarily catching the smaller fish. Sometimes they go out to fish with big nets in groups of approximately ten women and occasionally use nets for catching bait. There is also a group of ten spear fishermen who fish regularly during the evening. About five times a week on the fringing reefs and once a week out on the barrier reef. The bulk of the catch consists of small reef fish. But they also catch about 100 to 200 bigger fish (20 to 40 pounds) which they mainly sell to people in Lovu who export it to Suva receiving \$10 for three fish.

Agriculture

All the villagers farm and each family has its own area of land growing taro, kasava, papaya and yams, dalo, kava, banana, pineapple, and kumala (sweet potato) these are usually planted and harvested by the men. Slashing and burning of trees is the only way they clear patches of land to grow crops. There are no designated area for fruit, trees are distributed throughout the village with individual ownership but are usually shared. Pesticides are occasionally used on the farms for weeds. Most of the farm land is on the hill slopes due to the local geography this makes water drainage over the land a lot easier especially with the help of trenches providing a much more favourable environment for crop growth. This factor drew some concerns due to the issues raised by the Lomani Gau initiative which aims to reduce hill slope farming. This could also be a problem if the village extends due to no additional space or flat area of land. Most of the crops are being harvested for food every day. Kava takes longer to grow, about two and a half years and is harvested only once a week. None of the crops are being sold to Suva or the other villages around Gau.

Mangroves

There are several patches of Mangrove forest around Nukuloa. According to the men they are situated at Nawaikama, Yardi (a beach in between Nawaikama and Nukuloa), in front of the Nukuloa primary school and in Levuka. The people of Nukuloa do not use the Mangroves and say they understand the importance of conserving healthy Mangrove forests. There has been growing concern over the levels of coastal erosion and the women are keen to replant area of mangroves for increased protection and sediment accretion. There are even projects being set up for the youth to replant some of the mangroves that have been lost in the past years. The village is also intending to fill in some of the shallow areas of water as a means of reclaiming some of the land. This particular area of land is regularly flooded by high tides and increased wave action during storms.

Conservation issues

They all know about the presence of Frontier on Naviavia. But the workshop definitely helped them to understand the work that we are doing better. The existence of no-take zones in front of each village is also well known and all say that the boundaries are being respected. Even though there are no clear visual markers in the water. They say the Nukuloa no-take zone starts at a buoy in front of the seawall and extends to the start of the Levuka fishing zone, which is in front of the primary school. During this discussion it became apparent that sometimes they do fish in the no-take zone, especially during times of celebration (e.g. Christmas) when the village has lots of guests to cater for. They agreed that there was a need for some form of conservation and were generally pleased to have the opportunity to hear about the work being conducted by Frontier and were keen to continue attending workshops to gain more knowledge on their current health status.

C) Nawaikama

Socio-economic questionnaire Nawaikama

27-02-2009

Villagers Present	Age	Job
Tevita Mata	56	Farmer
Esala Kalakalakogau	43	Farmer
Saula Mono	58	Farmer
Livai Saunagali	38	Farmer
Tinai Bale	57	Domestic duties
Anaseim Ledua	41	Domestic duties
Temalesi V	43	Domestic duties

Mere Matai	49	Domestic duties
Timaina Vueti	72	Domestic duties
Litia Rabena	40	Domestic duties

Frontier staff: Keely Severn

General

There are 400 plus people in the village consisting of 65 families. There are 50 children aged 14-18, 98 children aged 6-13 and 50 children aged 0-6 years old. There is a preschool, primary school and secondary school in Nawaikama. There is also a vocational school where children learn about practical skills such as building, tailoring and cooking. 10 children are signed up to this school.

Fishing

There are 65 families in Nawaikama of which half of them fish each day by walking round the bay using lines, nets (once a week) and spear fishing. They do not use fibres to fish from but are sometimes taken to the barrier reef to walk along the reef at low tide for 2-3 hours using spears and lines. They fish alone and in groups both at night and in the day. Every fish caught is used irrespective of size and type. Most commonly caught species are Matu, Kawa kawa, Kaeatia, Saqa and Kaviace. Net size is 1-2 inches wide so average fish size is about 12 inches long. Matu is caught the most. Prawns, shrimps, crabs and lobsters are also caught and eaten as well as the black sea cucumbers. Turtles are only caught for special occasions. No fish are taken to Suva to be sold.

Agriculture

Types of crops include cassava, taro, yams, banana, papaya, sugarcane, kava, pears, chilli, breadfruit, lemons, oranges and mangoes. Each man has about 1 -3 hectare of land and all farming is done by hand. Lands are cleared by weeding the area, drying, control burning and ploughing. Crops are not taken to Suva to be sold. They use the method of shifting cultivation on a 3 year rotation.

Mangroves

The area of mangroves has increased over the last 20 years and is very slow growing. It is only in certain areas of the bay. Before mangroves were used as firewood but this has stopped as they keep the mangroves as protection for the fish. Children replanted mangroves in the 1990's.

Conservation Issues

The Turago ni Koro, Neumi, is in his 3rd year and was voted in by the villagers. The Village Head Man and 3 others are part of the Lomani Gau Committee; Matai, Ilisoni, Marika and Ana. 2008 was the last meeting of the Lomani Gau Initiative however there should be 4 meetings a year. There is a feeling of frustration and discontent as the Chairman Seru has not conducted any recent meetings and is not pushing for common objectives. The villagers do believe the Initiative is a good and positive idea but Seru is not acting as he should.

D) Somosomo

Socio-economic questionnaire Somosomo

11-03-2009

Village Statistics:

Population -121

Number of families – 26

Number of children – 26

* A large majority of the children were born in Somosomo village itself. All the children in the village will receive an education, and most will attend boarding school in the nearby village of Sawaieke.

Females Interviewed

Name	Age	Job
Lamieta Mokosoi	46	Domestic Duties
Amelia Savou	31	Domestic Duties
Wati Takayawa	48	Domestic Duties
Paulini Mawi	18	Domestic Duties
Iva Nailiicu	27	Domestic Duties
Cinaiasi Yaya	53	Domestic Duties
Emele Talatoka	45	Domestic Duties

Males Interviewed

Name	Age	Job
Josua Lailai	65	Farmer
Uraia Savou	75	Farmer
S. Vadei	58	Unspecified
J. Vuli	62	Unspecified
S. Malo	55	Farmer

M. Mayiti	54	Farmer
Savenea Wayasou Mayiti	55	Unspecified
Noa Ledua	48	Farmer
Emopi Lewalewa	32	Unspecified
Tevita Matai	32	Unspecified
Josua Tora	45	Farmer
Apisalome Salato	23	Farmer
Apate Jeie	56	Unspecified
Etomar Soqlal	60	Unspecified

Somosomo and the Lomani-Gau Initiative

The people of Somosomo have received relatively little information recently with regards to the Lomani-Gau Initiative. The Initiative meetings rely very much on Dr. Joeli Veitayaki and as a result, the last meeting was held around six months ago in 2008 when he was present.

However there is still a keen interest in the initiative and allegedly, funds are donated by the University of the South Pacific to the members in return for their attendance to the meetings. The only member mentioned in Somosomo was a male named “Kali”.

As for village understandings of the initiative, there is some knowledge regarding efficient use of resources, some farming practices and in particular waste management. As well as flushing toilets that direct human waste far out to the sides of the bay, there are also special places for the waste rubbish such as cans and plastic to be burnt safely.

Whether the importance of these issues is fully comprehended by the villagers with concerns to protecting the marine environment is somewhat unknown.

Mangroves

Mangroves in Somosomo have only ever been positioned to the “right” hand side of the bay and never in front as far as living memory serves.

The Lomani-Gau Initiative strongly discourages the cutting of the mangroves and after noticing the benefits the villagers ceased extensive cutting around ten years ago.

Currently there is no re-planting underway in Somosomo, although an interest was expressed to have help from Frontier and its volunteers in the near future to re-plant in a similar fashion to the village of Levuka.

In the past, the mangroves have been used by the villagers primarily for firewood as well as for the construction of Bures and similar structures. So even if it is for their own benefit, the importance of having mangroves nearby is on the agenda of the village.

Farming

In the village, it is the male population that is responsible for the farming. The farms lie on both hills and flat land, and on average the plots are twice the size of the community hall.

A wide range of crops are grown in the village which include: Tarot, Yams, Kassava, Sweet Potato, Bella, Kava, Cabbage, 4 varieties of Banana, Papaya, Mango and Pineapple.

Different crops are grown in different seasons and therefore are all harvested at different rates as the yield is dependant on the weather conditions (i.e. the flat land is prone to flooding in heavy rain)

Almost all the crops are grown entirely for consumption, with the exception of some Tarot and Kava which are exported and sold to Suva (and not around Gau Island).

As for farming practices, the importance of having big trees to benefit soil composition is widely understood, although “slash and burn” techniques are still employed to clear parts of the land.

Sometimes the use of pesticides (bought from Suva) are also employed, however no fertilisers are used and the crops on the plots of land are rotated every four to five years to allow nutrients to remain in the soil.

Fishing

The amount of times the villagers fish varies somewhat according to the information collected, however it is widely accepted that there is fishing activity everyday (except Sundays). Sometimes twice daily with fishing at night as well as the daytime.

It is mainly the female population who fish and the average catch is approximately 10-20 fish (with some in excess of 50 cm in length).

The main species that seem to be caught according to the understandings of fish species are: Snappers, Barracuda, Walu, Groupers and Trevallies.

* Allegedly when storms are looming ever closer, the numbers of fish being caught decreases sharply and so fishing activity is reduced.

Most of the fishing that occurs is done primarily with boats or bamboo rafts using a single line to fish. Although sometimes large nets are used on the beach/reef but this has proved problematic due to snagging on hard coral forms.

The people of Somosomo are aware of the “No Take” zones and obey them as their benefits are widely understood.

If the catch is too small whilst fishing, the fish are very likely to be thrown back. But also if the catch is large, the fish will be bought by “Kali” and exported and sold to Suva (where the

demand is high and all the fish can be sold at once). This proves to be a very good source of income for the village and is much more effective than having to employ others to sell fish to other villages around the Island of Gau.

Appendix 3. Newsletter produced by Dr Emma Wells and Huygen Theodoor van Steen.

The Society for Environmental Exploration, a UK based non profit organisation also known as Frontier, has been present on the Fijian Island of Gau since early 2006. They were invited by the University of the South Pacific through Dr. Joeli Veitayaki as a means of providing scientific assistance in relation to the conservation of the marine environment and development of fisheries.

During the three years that Frontier has been present on the Island it has established a number of regular survey sites on the fringing reef directly in front of 7 villages within the Sawaieke district. The surveys, also known as a baseline survey protocol (BSP), currently includes 14 dive locations, monitoring the abundance and diversity of the fish populations, algae, invertebrates and hard coral forms. In addition to BSP's Frontier monitors seagrass and mangrove habitats, assessing their distribution, abundance, species composition and associated fauna and flora. This has enabled Frontier to accumulate valuable baseline data that may be used to assess the current state of the fringing reefs of Gau. Frontier Fiji has also been successful in improving the awareness of the local sea turtle population through a number of workshops and teaching programs within the PADI AWARE programme.



Surveying the fringing reef



A Hawksbill turtle visiting the reef of Naviavia

At present Frontiers main aims are to help build environmental awareness, assist with resource management and develop sustainable livelihoods. These aims complement those of the Lomani Gau initiative, an Island council of elders and community members, which aims to help encourage the people of Gau to become more deeply involved in the conservation of their resources. The committee was formed four years after the Vanuoso district of Gau joined Fiji's Locally Managed Marine Area (LMMA) network in 2001 with the on-set of no take zones by each of the islands coastal villages.

Although the presence of Frontier on Naviavia beach is well known, their ambition to help combine local development with marine conservation is less known to the local communities. Frontiers desire to become more active in the local community and put its scientific capabilities to better use has instigated workshops around the west coast of Gau to improve relations and enable the dissemination of information directly to the local communities and those mostly affected by changes or restrictions in the use of their land and marine resources.

The workshops were organised with the assistance of each of the villages' administrators or Turaga ni Koro with the aim of providing a primary introduction to Frontier and familiarisation with its work and personnel. The first of these workshops were held in the villages of Levuka and Nukuloa. The workshops were opened by Mr Noa Ledua a friend of Frontier from the village of Somosomo who performed the sevusevu (an offering of kava). This was followed by a presentation by Dr Emma Wells who provided an overview of the general research conducted by the organisation and how Frontiers work is closely linked with the issues currently being addressed by the Lomani Gau initiative. With the use of visual aids, Dr Wells focused on the importance of the links between reef health, fish stocks, local activities and land use, further highlighting the value of mangroves and seagrass as fish recruitment grounds and the significance of adhering to no take zone restrictions. Paula Tora, also from the village of Somosomo, kindly assisted with the translation of the presentation to enable a full understanding.



Dr. Emma Wells using visual means to describe Frontiers work on the Island of Gau

The Lomani Gau initiative is eager to integrate resource management into the daily lives of the local people and to pursue certain issues related to areas of human activity. The workshop provided an open forum from which to discuss some of these issues such as coastal erosion, waste disposal, hill slope farming and no-take zones. This gave Frontier the opportunity to develop an improved understanding of the lifestyles and daily activities of the local communities and how they currently use their resources.

The important issue of coastal erosion was brought up by one of the villagers who showed deep concern for the impact this is currently having. The old seawalls have offered little defence and are starting to deteriorate providing little shelter from wave action. A more natural approach is now preferred with increasing enthusiasm for replanting mangrove systems. Not only will these provide greater protection in the long term from wave action but will assist with sediment accretion improving the clarity of the waters and encouraging juvenile recruitment in the area. A locally run youth group lead by Josepha Mua in Levuka was planning such replanting and will now be accompanied by the Frontier workforce for maximum productivity. In the village of Nukuloa similar concerns are arising with discussions of land reclamation to improve and extend defences, this will now be reinforced with mangrove replanting after an additional offer of help from Frontier.

The increasing use of flushing toilets within the villages poses the question of where much of this waste is delivered and how and if it is treated in any way. The frequent use of local water systems and intertidal areas for swimming, washing and fishing activity may be cause for concern as many of the local people are unaware of the health implications related to the improper disposal of such waste.

The reduction of hill slope farming, which is one of the main points of the Lomani Gau initiative, was not favoured by the inhabitants of one village with the only available farming land existing on the hill slopes. An increase in population could potentially reduce the land distributed between the members of the community. Other villagers argued that the hill slopes provide a better environment for farming during the rainy season whereby irrigation ditches redirect the excess water protecting crops and ensuring a full harvest. They rely on these crops not only for subsistence but to provide a small financial income necessary for the management and maintenance of their schools, churches and villages.



Frontier Fiji staff members Claire Ogg (left) and Huygen van Steen MSc (right) during an informal discussion session with the people of Nukuloa village

The no-take zones established by the Lomani Gau initiative are well known in every village but appear difficult to manage. During continued discussions between Frontier staff and the villagers it became evident that despite acknowledging the restricted fishing areas, adhering to such boundaries is often difficult especially during festive seasons or times of celebration. Sustaining the management of these areas is a major concern and Frontier Fiji hopes to work closely with the Lomani Gau committee to improve the management of the no-take zones in the future.

The informal manner of the workshop enabled Frontier to gain the trust of the local communities and speak more freely about some of the issues facing the sustainable use of their resources and semi-subsistence farming and fishing activities. The response was incredibly positive with enthusiastic discussions on how to address current issues. The overall outcome of the workshop was a huge success and Frontier will continue to work more closely with the local communities providing regular updates on the scientific research and information on the levels of fish stocks. The primary future aim of Frontier is to focus its conservation program around the education of the people of Gau to improve understanding and awareness. This hopes to be achieved through continued workshops and extending its educational program to the local community schools to install the value and importance of conserving natural marine resources into the younger generations.

Appendix 4. Datasheets used for the socio-economic surveys.

General Household Information

1	Name of interviewer				
2	Date of interview				
3	Time of interview	<i>am</i>		<i>pm</i>	
4	Village name				
5	No. of households in the village				
6	Name of household member				
7	Number of persons in the household	<i>Adults</i>		<i>Children</i>	
8	Number of regular income earners				
9	Main household income	<i>fishin g</i>		<i>farming</i>	<i>Other (state)</i>

Household Seafood Consumption

10	When was fresh seafood last eaten				
11	How much seafood is eaten	<i>Daily</i>		<i>Weekly</i>	
12	What species of seafood are eaten				
13	How is the household catch used	<i>Eaten at home</i>			
			<i>(%)</i>		
		<i>Given Away</i>			
		<i>(%)</i>			
		<i>Sold off</i>			
			<i>(%)</i>		

Fishing Activity

14	Fishing method used	<i>Gleaning</i>	
		<i>Hook and line</i>	
		<i>Spearing</i>	
		<i>Diving</i>	
		<i>Fish traps</i>	
		<i>Crustacean traps</i>	
		<i>Fibre</i>	
		<i>Raft</i>	
	<i>Other (describe)</i>		

15	What type of fishing equipment is owned								
16	Where does fishing take place	<i>Village waters</i>							
		<i>Fringing reef</i>							
		<i>Barrier reef</i>							
		<i>Lagoon</i>							
		<i>Mangrove</i>							
	<i>River</i>								
17	No. of people fishing in household	<i>Daily</i>				<i>Weekly</i>			
18	No. of trips per week for each person	<i>Per 1</i>		<i>Per 2</i>		<i>Per 3</i>			
19	How many people went fishing yesterday								

Individual Fishing Trip

Name of interviewer		Village			
Date		Time			
No. of people on trip					
Time of Trip	<i>am</i>		<i>pm</i>		
Duration of trip					
Means of travel	<i>Foot</i>		<i>Boat</i>		<i>Raft</i>
Fishing gear used					
Catch details	<i>Species</i>		<i>No. caught</i>	<i>Size</i>	
Location of trip					
Final destination of catch	<i>Eaten at home</i>				
	<i>Given away</i>				
	<i>Sold</i>				