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Editor's note

To begin this issue we welcome a contribution from Sébastien Larrue, who in *Giant clam fishing on the island of Tubuai, Austral Islands group: between local portrayals, economic necessity and ecological realities* reviews conflicting perspectives on the introduction of a management system for giant clams (*Tridacna maxima)*. Giant clams have become an important source of cash on this French Polynesian island, but exports to Tahiti threaten the sustainability of the fishery. The local situation is complex. On the one hand, the Tahiti Fisheries Department wants to monitor exports, while on the other, local island authorities debate a possible modernisation of the *rahui*, a traditional system of lagoon management. Many fishers do not support the claims of the scientific community, and in this they are widely supported by elders, whose views are in turn contested by certain 'wise men'. It makes for an interesting read.

Anna Tiraa continues the theme of *rahui* in a modern context with her contribution, *Ra'ui in the Cook Islands – today's context in Rarotonga*. She describes the efforts of a group of traditional leaders to reintroduce the *ra'ui* around the coast of Rarotonga. One leader noted "…there was resistance because the younger generation didn't know what *ra'ui* meant. They didn't realise that in those days the fish were bigger and they weren't scarce". Unfortunately, this is becoming a widespread lament, and one that will certainly have a serious impact on the content and transmission of local knowledge.

Based on their experience in establishing marine protection in the Western Solomon Islands, in the third article, *Early effects of a community-based marine protected area on the food security of participating households*, Pamela Weiant and Shankar Aswani seek to understand the contribution of some women's fishing

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activities to meeting livelihood needs, differences in household responses to a CB-MPA, and the relationship between food security and reef health. Their contribution is particularly valuable because in other studies of CB-MPA these topics have remained relatively unexamined.

Finally, we introduce a new eBook publisher, the International Resources Management Institute based in Hong Kong, and announce its first publication.

With best wishes,
Kenneth Ruddle

Giant clam fishing on the island of Tubuai, Austral Islands group: between local portrayals, economic necessity and ecological realities

Sébastien Larrue[1]

Abstract

Located below the Tropic of Capricorn some 670 km southwest of Tahiti, Tubuai is a high island in the Austral Islands group. Its 88 km² lagoon hosts large populations of *Tridacna maxima*, an edible South Pacific giant clam. Over the past decade, this giant clam, locally called *pahua*, has become a significant financial resource for some of the people living on the island. Growing quantities are being exported to Tahiti, raising concerns about the sustainability of this resource. The Tahiti Fisheries Department is therefore trying to set up a system to monitor giant clam exports, while Tubuai's local authorities, who are aware of the situation, are debating possible modernisation of the *rahui*, the traditional system of lagoon management based on temporary fishing bans. A significant percentage of giant clam fishers do not support the claims of the scientific community and insist that giant clam stocks are not endangered. This position has wide support among the island's elders, whose views about the biology of the giant clams diverge considerably from scientific concepts. In addition, according to most elders, oral traditions make no mention of any *rahui* on giant clams. This claim is, however, contested by certain 'wise men'. The end result is that traditions are being interpreted by many elders in such a way as to reject the need for any form of giant clam management in favour of immediate economic interests. The complex local context, with a wide gap between local portrayals, economic reasoning and scientific claims, makes it difficult to agree on a common approach to managing giant clam resources.

Introduction

Located south of the Tropic of Capricorn some 670 km southwest of Tahiti, Tubuai is part of the Austral Islands group. Tubuai is a high island located between the islands of Rapa in the south-east and Raivavae in the north-west. It is volcanic in origin and has a land area of only 45 km². In contrast, the lagoon, which is enclosed by a coral reef, has an area of 88 km². Fishers collect *Tridacna maxima*, a bivalve mollusc known locally as *pahua*, from the lagoon. This edible giant clam, which is found throughout the South Pacific[2] is strictly protected and is listed in Appendix II of the CITES agreement[3]. Only South Pacific Islands still have the right to collect giant clams and in French Polynesia, regulations permit the harvest of specimens of more than 12 cm in size.

Although giants clams have been widely harvested in most island groups of French Polynesia, particularly in the Society Islands, *T. maxima* is still abundant in the eastern Tuamotu Islands and Austral Islands where good-sized populations remain (Gilbert 2005). Nevertheless, the recent decline in stocks in a few Tuamotu island groups and in the Austral Islands is a cause of concern for the Ministry of Marine Affairs. This article is a follow-up to three fact-finding trips to the island of Tubuai where the giant clams have become a significant source of income for a small segment of the population.

In addition to discussing the harvest of giant clams, the trade channels used and income generated, this article provides another example of the 'gap' between local views, economic reasoning and scientific claims regarding resources — a gap that makes it difficult to agree on a common approach to the management of the clams.

Status of giant clam harvests on Tubuai

The issue of *Tridacna maxima* harvests on Tubuai is complex; it is difficult to determine who collects giant clams, how often they do so, and in what quantities. However, it is well known, at least on Tubuai, that everyone harvests them. In addition,

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2. The geographical distribution of *Tridacna maxima* covers the western tropical Pacific, the Red Sea and the coasts of East Africa (Rosewater 1965).
3. Washington Convention – Convention on International Trade in Endangered Species.

according to inhabitants, the *pahua* belong to everyone and breed in large numbers, from the beach out to the reef. Some believe that the *pahua* can even move about on the sandy bottom, rather like the migration of rock lobsters in the Caribbean…and the wildest tales can be told to a visiting *popaa*[4], who surely knows nothing about nature on the islands.

On Tubuai, everyone is more or less a farmer/fisher and giant clams are regularly harvested by the general population for subsistence purposes (Chabouis 1965). Of the island's 1979 inhabitants, 323 people, often heads of families, hold professional farmer/fisher cards. Nevertheless, certain families fish more than others and are recognised as 'good' giant clam fishers. About 10 families of fishers are more heavily involved in collecting *pahua*. Almost all giant clam fishers are located in the township of Mahu in the southern part of the island (Fig. 1).

a) Efficient artisanal fishing technique

All fishers basically use the same technique to collect *pahua*. They travel by boat to the middle of the lagoon, out to the coral heads or to the barrier reef, and insert the end of a t-shaped metal bar, about 60 to 70 cm long, between the two halves of the giant clam's shell. They then rapidly lever the bar to detach the clam from its coral base. Some fishers use what they call a 'hook' to detach the clams. This tool, which is similar to a gaff, is a flat metal pole about 60 cm long, one end of which is curved back. The hook is sometimes attached to the end of a two-metre pole, enabling fishers to detach clams from the surface down to depths of two metres. According to some reports, the hook has the advantage of pulling the *pahua* off the rocky base without damaging it (Larrue 2005). The hook is derived from a traditional sickle-shaped wooden tool that made it possible to remove giant clams from the coral without damaging them.

Normally, the clam meat is supposed to be extracted onboard the vessel and cleaned in the lagoon before being piled into a makeshift container, locally called a *touque* (Fig. 2). The *touque* is the basic unit for giant clam fishing and represents a capacity of about 20 kg of meat. *Touques* are made from old paint cans or plastic buckets that are taken out on the boat. A *touque* can hold between 100 and 140 giant clams, i.e. around 5 to 7 *pahua* per kilogram of meat, a quantity that obviously varies depending on the size of the clams.

Clam fishers' yields are based on the number of *touques* filled per hour. Of course, this number varies depending on the fishing site (abundance of the clams, accessibility, swell, depth), the size of the clams harvested (12 cm or more), and how experienced the person is at harvesting clams. These parameters therefore modify fishing yields considerably. In fact, depending on these variables,

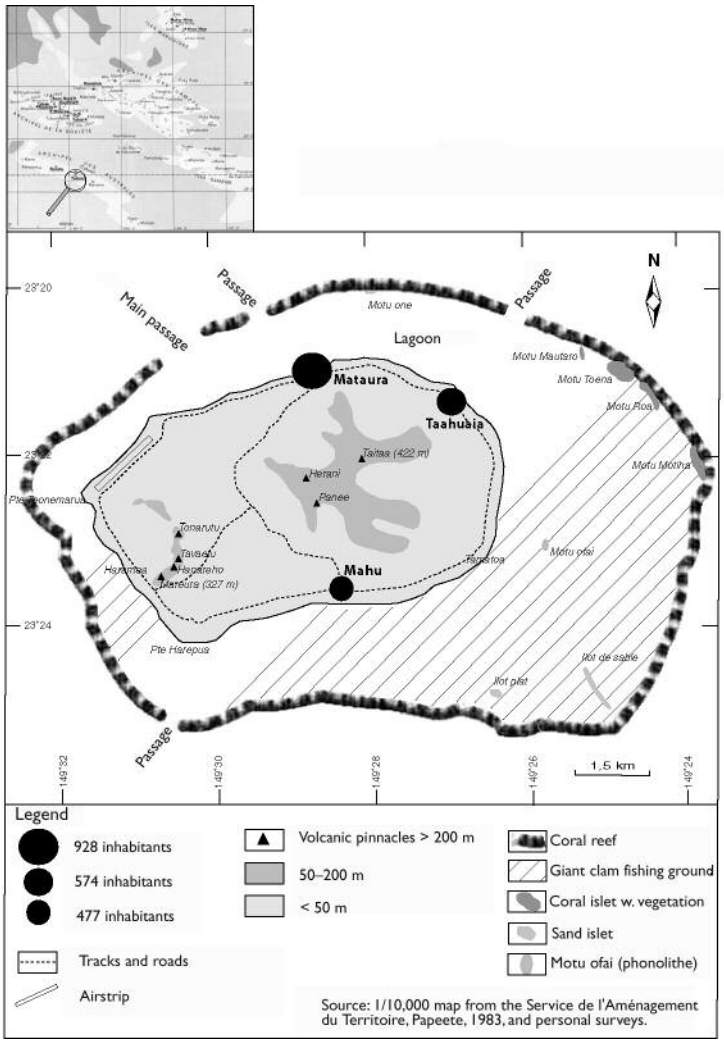

Figure 1. Map of Tubuai and its lagoon, showing the giant clam fishing areas.

4. Local name for people from metropolitan France.

Figure 2. **A touque of giant clams (*Tridacna maxima*). These clams (>19 cm long) were collected from Haramea. A *touque* is the local unit for giant clam sales, and represents 20 kg of *pahua* meat, i.e. 100 to 140 giant clams.**

filling up a *touque* with giant clams takes between one and two hours of fishing time. According to our surveys, on average it takes an experienced fisher 90 minutes to fill a *touque*. This time includes both collecting the clams and cleaning them before packing them in the buckets.

Today this artisanal fishery seems to be gaining in popularity. This obviously has implications for conserving the resource, especially as the income earned through giant clam fishing is relatively substantial.

b) Quantities harvested and pahua *fishery income*

As far back as people can remember, they have always harvested giant clams on Tubuai. *Tridacna maxima* are therefore part of the normal diet in the Austral Islands. Nevertheless, while people did fish for giant clams in the past, this was done mostly to meet local food needs. Today, however, although many people continue to eat *pahua* on Tubuai, except for Adventists who consider giant clams to be *tabu* (prohibited), the clams have become a significant and even vital source of income for many fishers.

According to our estimates, fishers on Tubuai harvest 1940 *touques* of clams per year, i.e. 40.64 tonnes of meat representing about 243,840 giant clams[5], with an overall economic value on Tubuai of some XPF 19,400,000[6]. In addition to this quantity, giant clams are occasionally harvested by the local community for food and by a few 'unregistered' *pahua* fishers. Except in rare instances, no fisher works alone; rather they fish in groups of two to seven people, often from the same family. Giant clams can be harvested all year round on the island of Tubuai, but the price of a *touque* varies (between XPF 8000 and 10,000) depending on three factors:

1. *Geography*: in Mahu, a *touque* generally sells for XPF 8000, while it can reach as much as XPF 10,000 around Haramea.

2. *Climate*: the state of the lagoon (e.g. heavy swell and low temperatures) affects fishing trips and can result in price rises. During the Southern Hemisphere winter, the price of a *touque* is about XPF 10,000 all around the island.

3. *Economy*: according to a few fishers, the price of a *touque* also varies depending on fishers' needs for ready cash. The same fisher might sell a *touque* for XPF 8000 at the beginning of the month and for XPF 10,000 at the end of the month if he needs money. Similarly, the frequency of fishing trips also depends a great deal on how much fishers feel they need money. We noted, as we will explain in further detail below, that fishers are not 'in a rat race for income' but fish on an 'as needed' basis, i.e. they do not go fishing if they feel that they still have enough money.

Not all fishers are at the same level in terms of income. In fact, depending on the person, the number of *touques* collected each month varies from 1 to 45, bringing in monthly incomes of between XPF 8,000 to 360,000, respectively. All the fishers interviewed work to fill orders, some of which are placed on a regular basis whereas others are changeable or occasional. This situation reflects the existence of several commercial channels for *pahua* on Tubuai.

In addition to these regular fishers, there are also associations and religious movements that carry out large-scale, one-off harvests for specific events. This is particularly the case for the Mormon community, which every year, in April, sends about 27 *touques* to Tahiti to finance travel costs for their young people. Some local people said that in April

5. Estimate based on an average of 120 giant clams/*touque*.
6. Pacific franc; XPF 100 is equal to USD 1.00 (April 2006)

2005, the association *Ia tauturu ia na* shipped out nearly one tonne of giant clams harvested in one day by 11 people.

A preliminary study carried out on Tubuai by the Fisheries Department indicated that giant clam resources would be endangered by harvests of more than 4 tonnes of meat annually (Gilbert 2005). Therefore, even if there were errors in the models used to set that threshold, the difference between the maximum quantity recommended to ensure the sustainability of this resource and the quantities actually collected locally (i.e. more than 10 times greater than the replacement threshold) is such that there can be no doubt that the giant clams are currently being overexploited.

Only a few fishers, who at present have little involvement in obtaining income from *pahua*, have reported that the number of giant clams is declining everywhere around the island and has been for the past five or six years, i.e. since commercial channels have increased.

Will increasing commercial channels kill this prized resource?

On Tubuai there are two major channels for the giant clam fishery: (1) fishers fill orders from Tubuai's 'non-fisher' population, and (2) fishers respond directly to requests from Tahiti for supplies. Of course, it is also possible for certain fishers to use a *hybrid* system, i.e. based on a combination of both local demand and orders from Tahiti. There are also additional minor channels.

a) Origin of demand for giant clams

The first channel, i.e. the local channel, consists of orders from people on Tubuai who order one to four *touques* of *pahua* from certain families. When the fisher has enough orders, he puts them together and goes fishing. Payment is made directly from hand to hand, i.e. between fishers and local customers, with no middleman. This is probably the most visible channel. Questions then arise about where local orders end up: Why do people on Tubuai order giant clams? Do they eat them themselves, sell them, or send them as gifts to family on Tahiti or Rurutu?

In fact, people on Tubuai who order clams from fishers say that they do so to send them to relatives on Tahiti. This case often involves 'gifts' for festive occasions, but certain families buy *pahua* from relatives who are still living on Tubuai. Whatever the situation, this process is based more on a form of 'the exchange of friendly services' than on commerce. Nevertheless, there may be cases where this system of family solidarity should be verified as some people place orders with fishers every month, supposedly to 'send to their relatives'.

We consider that there are two possibilities: either their relatives on Tahiti eat practically nothing but *pahua*, or they resell these giant clams to hotels and restaurants. Alternatively, the shipments are not based on aspects of kinship at all but rather are direct responses to orders from hotels and agro-food industries on Tahiti. Within this first channel then, there are people on Tubuai who act as 'middlemen', i.e. they place orders with fishers and resell the giant clams to contacts in Tahiti (restaurants, food vans, major hotels, exporters, supermarkets, etc.).

The second channel consists of fishers working directly on orders for people in Tahiti. This channel is less visible and is extremely difficult to obtain reliable information on. In principle, the fishers involved ship the orders to Tahiti but do not leave Tubuai. In a very few instances, fishers such as those who live on Mataura, supply *pahua* to the few snack bars on the island.

According to the elders, in the past people harvested *pahua* to sell it on Tubuai. At the time, this simply involved sales for local consumption by people on the island, often during festive occasions. People harvested about three *touques* of giant clams per day and sold the *pahua* for XPF 100/kg, which was very little income for work they considered tedious. Fishers today are satisfied to see a *touque* sell for XPF 8000–10,000. Obviously the current situation bears no relationship to the time described by the elders when there was no commercial channel worthy of the name on Tubuai.

One of the first 'official' commercial giant clam operations on Tubuai was linked to the initiative of a *popaa*, who in 1990 sent giant clams to Tahiti on a regular basis. A middleman there received the *pahua* and supplied hotels, restaurants and supermarkets on Tahiti. The clams were packaged to meet the health standards required for large retail stores. The quantities of *T. maxima* sent equalled about 500–600 kg of meat per month. At the time, the fishers who worked for the restaurant owner each harvested 50 kg of meat in four or five hours of fishing. This was apparently the maximum yield and so the people who fished had the reputation of being good giant clam fishers. Today, that person no longer conducts this business, but others have taken over the work.

On Tubuai there are only two ways of shipping goods — by boat or by plane. The plane (ATR 72)

makes an average of four return trips a week. Giant clams are shipped by air for urgent but costly orders. The cost of air freight is high, i.e. XPF 6000 to send one *touque* (20 kg) of giant clams from Tubuai to Tahiti. People who say that they are sending their giant clams to relatives often do so by plane. However, this is quite expensive for a family shipment when the local cost of the *touque* is added in, i.e. a total of XPF 16,000 for one *touque* shipped to Tahiti.

Given the prohibitive cost of air freight, a large proportion of exports appear to be carried by boat except when the shipments are urgent. Although the boat makes only two return trips a month, the low shipping costs compensate for the inconvenience. For shipping by boat, the giant clams are packaged in 'flour sacks' that hold about two *touques*. The cost of shipping one sack is XPF 1000, i.e. one-twelfth the cost of air freight. A *Tuhaa pae* employee in charge of registering all items loaded estimated that slightly more than 40 *touques* of *pahua* are shipped each month from Tubuai to Tahiti, i.e. about 800 kg/month. According to our informant, Raivavae exports much more, i.e. about 2,000 kg/month. However, we think this is an underestimate, since a single Tubuai family specialising in giant clams harvests an average of 45 *touques*/month, i.e. 900 kg of meat. Given this information, the Tahiti Fisheries Department is trying to clarify the situation by obtaining better estimates and — with the support of local authorities — has set up controls for this purpose through the Rural Development Service (SDR) on Tubuai.

b) A sensitive local situation

It is not always easy to obtain information about giant clam fishing on Tubuai because it is something of a 'secret fishery' that islanders do not discuss readily with 'outsiders'. In fact, there are no written records on the giant clam fishery and the Mayor's Office has no information or reports on it. Giant clams account for significant financial revenues for fishers, and are even an essential source of income for some. Only a few fishers dared to respond to the embarrassing question: 'Is income from *pahua* vital for your family or is it just extra income?' by admitting that this income was essential for their households. People are afraid to say that *pahua* can generate good levels of income because they fear that the Territorial Government will want to 'tax' it.

Given this setting, the information we did obtain tended to show that the issue of the possible management of giant clams is a source of conflict. In addition to work by the Fisheries Department, local authorities (the Mayor's Office, Municipal Council and Council of Elders) have for several years been discussing the possible implementation of a *rahui*[7] on giant clams. On the island, the authorities are aware that the *pahua* is subject to commercial-level operations. However, it was at the specific initiative of the Tahiti Fisheries Department that discussions about this matter recently resumed. In short, the Mayor's Council, assisted by the island's 'wise men', is divided on this matter.

According to a few members of the Council, a *rahui* must be put in place to ensure the survival of the giant clams, but much hard work still needs to be done to convince everyone of this. According to several reports, managing *pahua* stocks by means of a *rahui* is vital to conserve these resources. However, many islanders believe that there are never-ending supplies of *pahua*.

It is particularly noteworthy that, contrary to expectations, the old people, fishers or members of the elders, are for the most part against the *rahui* although they are supposed to be the guardians of tradition and resources. A few elders state that there has never been a *rahui* on giant clams on Tubuai and they do not understand why there should be one now. In general, *pahua* fishers between the ages of 30 and 45 do not seem to be particularly opposed to a *rahui*. Many are fathers with children but, more importantly, they are better informed than the old people about a possible decline in the resource. These adults seem to be more concerned with the future of *pahua* for their children. However, this is not the case with the elders, who seem to want to profit as much as possible from the resource without really worrying about the future. While some do not want to hear anything about a *rahui* on giant clams, they would like a rahui to be put on the price: 'No less than XPF 20,000 a touque'.

Half of the Mayor's Council is still in favour of a *rahui*, while the other half is against it. Given this conflict, the role of the elders must not be underestimated. In invoking the fact that no *rahui* on giant clams exists in oral traditions, it is apparent that the effect of their opinions is to swing the situation in favour of uncontrolled fishing.

7. *Rahui* is the traditional system for managing lagoon resources. Sites were closed to fishing for a set time or a ban on harvesting specific species was imposed until such time as the ban was removed by the Council of Elders or 'wise men'.

Local concepts about the *pahua* fishery on Tubuai

Faced with apparently increasing commercial exploitation, we felt that it was important to find out whether the people of Tubuai attributed any symbolic importance to giant clams that could be used to limit harvests.

a) What socio-cultural position does the giant clam hold for fishers?

The giant clam is apparently a food that people are more likely to eat during festive occasions. It is very commonly eaten at weddings, during a *ma'a*[8] or during the *heiva*[9]. According to fishers, it is much less commonly eaten during regular meals 'because collecting *pahua* is a lot of work'. In contrast to Raivavae, which has a few legends about giant clams (Lherbier 1944), Tubuai has none, and the bivalve itself is not subject to any prohibitions[10]. According to elders, *pahua* have never held any kind of symbolic meaning on the island, unless it has been forgotten. Apart from the ban on bringing the shells back to land, they do not know of any specific prohibitions relating to the *pahua*. However, the giant clam is also known locally as *te metua vahine o te miti* (the mother of the sea), which means that it plays an important role in the rest of the ecosystem, and in former times priests used giant clam shells for religious rituals on the *marae*[11] (Audran 1926).

What is perhaps more interesting is that during a *rahui*, the prohibited area was marked out by necklaces of giant clam shells attached to the trees at the boundary of the *tabu* zone. These areas were monitored by people called *toohitu*, 'guardians of the sea'. During the *rahui* on giant clams, the sea was divided up, and each part had a name. However, the elders can no longer recall the names. When the *rahui* was removed, people would go out fishing together, which would ease tensions between families. Traditionally, giant clams were harvested with pointed sticks made from the wood of the *aïto* (*Casuarina*) root, and the meat was removed with bamboo 'blades' (Gilbert 2005).

Apart from this sketchy and largely irrelevant information, we were not able to get any other information on the socio-cultural position of giant clams on Tubuai. This suggests that it would be difficult today to base a *rahui* on any kind of symbolism in an effort to protect the resource by referring to tradition. On Tubuai, the only symbolism that giant clams currently seem to have can be summed up in terms of financial value.

b) Is the pahua endangered on Tubuai? Fishers' responses

People are increasingly attracted to the income generated by *pahua* fishing. The islanders consider that the giant clams belong to everyone, and individuals are free to harvest as much as they like, as long as 'they're not afraid to get their feet wet going out to get them'.

When first asked about their purpose in fishing for *pahua*, many fishers responded 'to send to relatives in Tahiti.' People may not respond truthfully either because they are afraid of being taxed on this fishery or because the authorities on Tahiti might put restrictions on the collection of giant clam. At present, fishers are suspicious of territorial authorities and of what is being said about the decline of giant clam stocks. Fishers also challenge certain scientific information that was poorly understood during meetings with the Fisheries Department. For example, they do not agree that a period of five years is needed for giant clams to reach their 'adult stage'. Fishers think that clams reach this 'adult stage' in two to three years. However, there is some confusion in their minds between the 'adult stage', which — from an ecological point of view — corresponds to sexual maturity, and the legal fishing size of 12 cm. In fact, fishers believe that the 'adult stage' corresponds to the authorised size for collecting giant clams.

Almost all fishers interviewed had been harvesting giant clams for 15 to 20 years and sometimes longer. They said that they had not noticed any decline in stocks with some saying that there were now more giant clams than before. According to the SDR Officer on Tubuai, 'There are giant clams everywhere around the island, except between the airstrip and the pass'. This informant also said that the shellfish is recolonising areas it had disappeared from between Mataura and the first motus (islets) in Mahu.

In fact, fishers do not believe that stocks are declining as scientists claim. In addition to the reasons mentioned above, they think that collecting giant clams is not harmful to the renewal of the resource for two main reasons. The first is based on a cultural argument or recall of tradition — which is oral

8. *Ma'a* refers to a traditional Tahitian meal with food steamed underground in a traditional oven, but also to a social or family gathering.
9. *Heiva*, which used to be called *tiurai*, is a long period of festivity during July.
10. Except for Adventists who do not eat it.
11. *Marae* are religious edifices and traditional sacred sites. They usually consist of raised platforms of various levels built from stone, on which diverse ceremonies were practised.

and therefore difficult to verify — that claims that people have harvested giant clams for many generations without destroying the stocks.

The second is linked to practices. In the past, custom dictated that giant clam shells were never brought back to land (except for specific uses related to religious rituals). They had to be thrown back into the lagoon they had been taken from. This *tabu* had two bases: (1) to avoid cluttering the beaches with piles of shells that could cause injury, and (2) to allow 'reproduction of the shells'. This practice is still in effect and the Tahiti Fisheries Department encourages fishers to follow it.

Many fishers think that the shells come back to life in the lagoon. Some fishers said that they had noticed that after six months, the shells that they had thrown back into the lagoon 'came back to life', allowing renewal of the giant clams. In this regard, some 'newly arrived' fishers who did not respect this *tabu* were strongly criticised by the community for bringing giant clam shells back to the land. Since then, everyone has been expected to respect the prohibition and are persuaded that they are promoting giant clam reproduction when they leave the shells in the lagoon. Nevertheless, as can be seen in Figure 3, not everyone is following it. According to one fisher on Tubuai who was still living on Tahiti in 1950, there were as many giant clams between Paea and Papearii as there are on Tubuai. If there are not many giant clams on Tahiti now 'this is indeed because people brought the shells back to land'.

Secondly, fishers think that cleaning the giant clams in the lagoon 'releases' and scatters the shellfish's eggs, which then develop into new specimens. Of course, as with the miraculous 'resurrection' of the shells, this is not the case. According to the Fisheries Department, at most this process might stimulate and speed up reproduction in nearby giant clams by releasing pheromones that act as sexual stimuli. In no case do the eggs thus released develop to term.

Given the current state of affairs, therefore, fishers do not see the point of setting up protection zones for giant clams since they do not believe that their fishing habits are a threat to the resource. Their opinion is supported by the fact that there are still lots of the shellfish almost everywhere in the lagoon. However, although they feel that giant clam stocks are not actually endangered, opinions seem to be divided. Some fishers have noticed that the number of giant clams has declined all around the island. Based on what they have observed, the few fishers willing to admit this are not against the idea of an updated and well-adapted *rahui*. For the moment, they are in the minority. However, it is important to note that this group consists of fishers who are not dependent on income earned from giant clams, which allows them a certain measure of detachment. This is not the case for fishers who are more heavily involved in sharing the proceeds from the sale of giant clams.

c) You said tabu zones?

Given the situation described, we tried to find out if certain ancient beliefs linked to the French Polynesian concept of *tabu* and sacred sites still existed, particularly regarding possible forms of traditional management of giant clam stocks.

However, traditional customs, including those relating to the sacredness of sites and fishing practices, seem to have disappeared from Tubuai. Even the *marae* are no longer given any special attention and are generally overgrown by vegetation and treated with indifference[12]. For example, in Haramea, a 1.2 m phonolite still standing on the ground, and locally called 'the ringing rock', was once used to call people together, but to the best of our knowledge, no one remembers its precise history. According to legend, the island lost its navel, which was carried off to Maiao[13] by the bird guardian who was disappointed in the behaviour of man. No-one remembers the exact reasons behind this disappearance and rare are those who

Figure 3. Opening giant clams with a knife on the beach. Theoretically it is 'prohibited' by custom to open *pahua* on the beach and to leave the shells there. This ban has also been issued by the Tahiti Fisheries Department, which advocates throwing the empty shells back into the lagoon to facilitate settlement of juvenile giant clams.

12. Except by a few people who are trying to maintain the island's cultural heritage.
13. High island in the Society Group (Windward Islands).

can still tell the entire history of *Motu Ofai*, the only phonolithic volcanic island in the lagoon.

In practice, the local communities fish all around the island, except in those spots where the geomorphology of the lagoon is not suitable for harvesting giant clams. When they want to collect giant clams, fishers from Mataura go by boat in the direction of Haramea or the first motus, *Mautaro* and *Toéna*, 6 km offshore from Mataura. This entails fuel costs and probably explains why there are very few *pahua* fishers in Mataura. In Tamatoa/Mahu, people go directly out from where they live and practically fish in front of their houses a few hundred metres into the lagoon and all the way out to the reef. In Haramea, the fishers we encountered said that they also went across from their homes to the lagoon and out to the reef. Many said that they had been harvesting giant clams for 20 to 30 years and had not noticed any decline in the *pahua* stock.

It appears that fishing areas are no longer prohibited to permit renewal of resources. The community has no recollection of the last time a *rahui* was used on Tubuai. Furthermore, some elders themselves say that these bans never involved giant clams. Nevertheless, according to a few reports, the *motu pahua* are the result of long-term dumping of giant clam shells by the elders. According to these reports, it was traditionally forbidden to get rid of the shells elsewhere in the lagoon. The gradual build-up is supposed to be the origin of the motu[14]. Today it is difficult to clarify matters: is this a simple myth that has become part of the collective memory or is it the surviving traces of historically based facts?

Conclusion

There is little awareness of a possible decline in *pahua* and many fishers seem to be convinced that this resource is inexhaustible, or at least that is the impression they give. However, we did note that near the village of Mahu, i.e. in the very area where the largest number of giant clam fishers can be found, some 120 to 140 *pahua* are needed, on average, to fill a *touque*. On the Haramea side, 90 to 100 giant clams are enough to fill one. Although large giant clams continue to be harvested near Haramea, it does seem that the fishers in Mahu are now harvesting large *pahua* from younger generations. In addition, several fishers admitted that they had to go into increasingly deeper waters to find large giant clams.

In terms of traditional lagoon resource management, the old practices have been 'forgotten'. The islanders know that the *rahui* system was used on Tubuai, but very few people know exactly when the system was abandoned. Thus, there are no longer any areas temporarily closed to *Tridacna maxima* harvest, either in fact or in the memory of oral tradition.

Certainly there are still large numbers of *Tridacna maxima* on Tubuai, but if the commercial sector continues its uncontrolled growth, we believe the situation could quickly become critical. A few indigenous people share this opinion and tend to favour putting a *rahui* in place. According to them, giant clams will go the same way as *remu* seaweed[15] if no bans are implemented. But most importantly, vestiges of oral tradition seem to be being used by certain elders as a shield to protect their economic interests. In fact, many of them are directly involved in obtaining revenue from the giant clam fishery. The existing gap between the local portrayal of the situation, economic reasoning and scientific claims makes joint management of giant clam resources very difficult. In addition, this fishery is vital for numerous families on Tubuai, whose standard of living is one of the lowest in French Polynesia.

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14. This version appears rather far fetched to us and we think that it is more likely that this pile of shells is the result of the lagoon's own natural selection or hydrodynamic segregation processes.
15. This type of seaweed was harvested in large quantities by the community and sold with no control measures. Today it has almost disappeared.

Ra'ui in the Cook Islands – today's context in Rarotonga

Anna Tiraa

Though I had heard the word *ra'ui*, until I started working in the environment field I was not sure of its meaning. As a consequence of my work, I started to learn more about *ra'ui* through reading and talking to other conservationists and elderly people. Only then did I begin to understand more about this traditional practice.

When the Koutu Nui (formalised group of traditional leaders) embarked on reintroducing the *ra'ui* around Rarotonga's coast, the late Akaiti Ama Tamarua Nui Mataiapo (traditional chief) remarked to an overseas journalist, "There was resistance because the younger generation didn't know what *rau'i* meant. They didn't realize that in those days the fish were bigger and they weren't scarce."

Background

The Cook Islands consist of 15 small islands with a total landmass of only 237 km^2, spread over an ocean area of 1,830,000 km^2 in the South Pacific (between 9° and 23°S latitude, and 156° and 167°W longitude). The islands stretch out from Samoa to the west and French Polynesia to the east, and are divided into a Northern Group consisting of six lower-lying islands and a Southern Group of nine mostly higher islands. The capital, Rarotonga, is the largest (6719 ha) and most populated island of the group.

The most recent population census in December 2001 showed that the official resident population of the Cook Islands was 14,990 with approximately 9,500 living on Rarotonga. Large numbers of Cook Islanders have migrated to New Zealand, Australia and elsewhere over the years, generally seeking better employment opportunities.

The major income earners for the Cook Islands are tourism, black pearls, fishing, agriculture and offshore banking (Cook Islands Government 2003). The top performing economic sector is tourism, which has developed considerably since 1971 when only a few hundred tourists visited the Cook Islands compared to the year 2001, when a record 75,000 people holidayed in the country (Cook Islands Government 2003). Rarotonga, as the gateway to the Cook Islands, receives the most visitors, while Aitutaki is the second major destination. Tourism and associated industries have generated an average 80% of gross domestic product in recent years (Cook Islands Government 2003).

Legal systems

The Environment Act 2003 provides national legislation for the protection, conservation and management of the environment in a sustainable manner. Responsibility for managing the environment is divided between several government ministries, agencies and councils with non-government organisations also helping to address environmental concerns.

The Environment Act currently applies to Rarotonga, Aitutaki and Atiu. For islands not covered by the Act, the island council is the main body with the authority to enact protected areas (PA) under the Local Body Act. Of these, only Rakahanga and Pukapuka have developed specific by-laws to establish and manage *ra'ui*, though there are intentions to do so for other islands. For example, the people of Atiu, owners of the uninhabited island of Takutea, have started preparing draft bylaws to protect the biodiversity of the island.

On Aitutaki there has been considerable discussion on giving legal status through bylaws to *ra'ui*. However, this has not progressed any further mainly because the island council is unsure of its jurisdiction and lack of local drive to pursue *ra'ui* development. Furthermore, the current bureaucratic system of enacting by-laws for PA is extremely time-consuming (Saul and Tiraa 2004). Lack of knowledge of the required procedures has resulted in very few new strictly environmental bylaws being established in recent times, although some have been established for the control of economically important resources such as trochus[1].

1. A marine gastropod with a valuable shell that is exported for manufacture of mother-of-pearl buttons.

There is no formalised national system of PA in the Cook Islands. A consultancy was recently completed, under the National Biodiversity Strategy Action Plan (NBSAP) to determine a suitable national system for PA (Saul and Tiraa 2004). This showed differences throughout the country in the way existing marine and terrestrial PA have been established and managed. Traditional leaders, island councils, landowners and government have all played roles in establishing and managing these PA.

Saul and Tiraa (2004) recorded 36 known PA in the Cook Islands, 34 of which include the marine environment. These consist largely of areas not covered by legislation, with the majority being community owned. Suwarrow National Park, Rakahanga rahui (= *ra'ui*) and Pukapuka rauwi (= *ra'ui*) are the only PA with legal status. There may be other PA, but as yet there are no systematic, complete data on the total number of PA in the Cook Islands. The atolls include both the land and adjoining lagoons in the PA.

The Outer Local Body Act 1987 and the Environment Act 2003 are specific with regards to the development of PA in the Cook Islands. The Local Body Act 1987 allows island councils to make bylaws to regulate and control the use of any reserve or park vested under their control. The Environment Act provides for the establishment of a PA proposed by an Island Environment Authority. However, neither act provides regulations to assist PA established outside of these bodies.

History of *ra'ui*

Traditional pre-contact societies of the Cook Islands had a complex system of marine and land tenure that allowed delineated and enforceable control over the use of land and sea. The customary prohibition known as a *ra'ui* was one example of such control.

A *ra'ui* was imposed by the chief of the tribe or the head of the landowning lineage to control the use of resources or facilities. These included land areas, lagoons, rivers, freshwater ponds, lakes, swamps, fruit trees, coconuts, birds, and other wildlife such as turtles and coconut crabs for conservation management (Utanga 1989). The system bans the harvest of food resources for a set period to enable stocks to increase. Traditionally, when a *ra'ui* was lifted, it could be moved to another area or re-established at a later time in the same area, sometimes after a very brief harvest period.

The system was not perfect. Infringements occurred and penalties were imposed. For example, in Atiu, one of the islands in the southern group, depending on the severity of the offence, punishments ranged from execution, being set adrift in a canoe, banishment from the community, deprivation of certain land rights, to being physically beaten or having one's house, canoe, crops or other property destroyed. In addition to physical punishments, supernatural forces (*tapu*) were invoked to inflict further penalties for breaking traditional rules (Crocombe 1989). On Pukapuka, in the northern group, a common punishment is relegation to child status in the community, losing the rights and respect afforded to an adult for a certain period (Munro 1996). This punishment is still enforced today on Pukapuka.

The elimination of customary ownership of the lagoon and sea under the Cook Islands Act 1915 took away the right of landowning units to impose enforceable controls, weakening management regimes in these areas, particularly on Rarotonga. The lagoon and seas now belong to the Crown. The last marine *ra'ui* decreed by a traditional chief on Rarotonga was in the 1950s (Evans 2001).

Though the authority of the traditional chiefs has been eroded considerably since European contact, the Cook Islands Government has allowed traditional leaders to maintain an advisory role to the government by establishing the House of Ariki, a formalised group of high chiefs (Ariki) and the Koutu Nui, consisting of chiefs and sub-chiefs (Mataiapo and Rangatira).

The state of Rarotonga's marine environment — in particular the depletion of seafood resources found in the lagoon and on the reef slope — became a matter of considerable concern to the Koutu Nui in the late 1980s and early 1990s. After a number of public meetings in 1997 relating to the development of a Tourism Master Plan, at which the public expressed concern about Rarotonga's marine resources, the Koutu Nui decided to attempt to re-establish the *ra'ui* system in some areas of the lagoon and reef slope (Passfield and Tiraa 1998).

A total of five areas were initially selected in which to implement the *ra'ui*. A series of consultations with stakeholders in these areas showed that there appeared to be sufficient support to give at least some chance of success and the *ra'ui* were declared in 1998.

There is no legal basis for the *ra'ui*. Rather they rely on respect for traditional authority (Reid undated). Any poaching is assumed to be dealt with by rebuke and community pressure. The main purpose of the *ra'ui* is to help protect the marine environment, and to contribute towards an increase in marine life for present and future generations (Passfield and Tiraa 1998).

Socio-economic benefits of the *ra'ui*

Preliminary suggestions of reviving the *ra'ui* met resistance from some community members who perceived that access to resources would be lost for those who fished the area. As *ra'ui* areas range from about 300 to 800 m in width it was explained that fishers could continue to fish outside the *ra'ui* areas. The fact that nobody relied on the resources in the lagoon for their livelihood also meant that the negative impact on the community would be minimal.

The *ra'ui* appeared to meet with obvious success within a comparatively short time of 12 months. Surveys conducted at the beginning of the *ra'ui* and later by the Ministry of Marine Resources indicated an increase in abundance of marine life. Education and awareness activities were used to promote the *ra'ui* extensively during its early stages and support for it grew. This resulted in the number of ra'ui increasing to a maximum number of 12. Each *ra'ui* differs in its execution. Some are short-term involving rotational closures of nearby sites, some are long term, while others involve no or partial take. The management measures for *ra'ui* sites are continually evolving; for example, part of the Tikioki *ra'ui* has now been permanently reserved (*ra'ui mutukore*).

However, the active community consultations common at the onset of the *ra'ui* became less frequent with time. Dissemination of information on the *ra'ui* through the media and other channels also declined after an initial flourish. The resulting lack of awareness has contributed to uncertainties about the current status of some *ra'ui* and unfortunately reduced support for them with infringements increasing in several.

Because of poaching problems, the traditional leaders who initiated the Pouara *ra'ui* (east side of Rarotonga) are asking for legal recognition of their *ra'ui* under the Environment Act 2003 and have commissioned a management plan towards this end. Some people believe that this will make the *ra'ui* more effective. However, this may not be the case, as although the Environment Act caters for preparing management plans for recognised PA, it is notably silent about enforcing compliance with such plans (Saul and Tiraa 2004).

Insufficient monitoring, control, and surveillance capacity is one of the major constraints to enforcing *ra'ui*. The increased poaching in some *ra'ui* areas shows that communities lack the capacity to prevent this harvesting in these areas.

Tourism operators have exploited the *ra'ui* status with some accommodation establishments marketing themselves on the basis of their proximity to a marine PA. As one accommodation owner said, "Tourists like to go to a place that values tradition." Other tourism activities include accompanied snorkelling activities and boat tours to some *ra'ui* areas.

There is no direct benefit to the traditional owners of the land adjacent to the *ra'ui* areas, who before 1915 had ownership and exclusive rights to the lagoon areas as well. In contrast, the Takitumu Conservation Area, a forested land-based PA on Rarotonga has provided direct financial benefits to the three clans who own the land through ecotourism.

There are, however, some direct and measurable financial benefits for communities who exploit the *ra'ui* when they are opened for harvesting. For example, in 2000, the first commercial harvest of trochus on Rarotonga came from the Nikao *ra'ui*, located on the northwestern side of Rarotonga. Two tonnes of trochus were harvested and the shells were exported to New Zealand. The harvest raised NZD 35,000 for the community.

Other direct financial benefits from the *ra'ui* are minimal as resources harvested from the lagoon are mainly for subsistence purposes. However, marine resources have probably become more abundant in other areas of Rarotonga's lagoon as a result of a spillover effect as resources reach high population densities within the *ra'ui* area. A value could be calculated for these resources based on import substitution, i.e. people eat locally available foods rather than imported food sold by shops.

Not everyone agreed with the move towards legal recognition of the Pouara ra'ui. My late father, Tane Tiraa who held the chiefly title of Tuakana Mataiapo, was against it. I remember talking to him about this. He said, "The legalization of the *ra'ui* will weaken the *mana* (power) of the traditional leaders." I debated this point with him, suggesting that codifying the restrictions would give the *ra'ui* more teeth as people were not respecting it. When I now reflect on this discussion I am reminded that even under legally backed environmental initiatives and pre-European management systems, infringements occurred. The difference today lies more in the imposition of penalties, which are enforceable in a court of law with legally backed systems. Dorice Reid Te Tika Mataiapo said, "We would love our people to learn through education not legislation. Our approach to conservation is not through fear but through respect." The balance therefore may lie in incorporating traditional management regimes in modern legal systems.

Indirect financial benefits can be assumed to accrue based on increased tourism related to the *ra'ui*, and an associated increase in employment and revenue for accommodation establishments and tour operators. These benefits are, however, difficult to quantify without conducting a detailed study. Further financial benefits could be gained by the community if a system was in place requiring tourism operators utilising the *ra'ui* areas to pay a small fee to contribute to their upkeep (e.g. signs, education and awareness activities, etc.).

Aside from the potential income, there are also probable health benefits for people who eat fresh seafood rather than processed and often fat-laden commodities such as tinned corn beef from the local shops. However, because there were no baseline dietary surveys before the *ra'ui*, it is not possible to verify this.

There are also educational benefits for the younger generation of the community as *ra'ui* areas have been utilised for school field trips. However, while biodiversity conservation ethics may have been conveyed to students through these educational trips, the adult population has been less exposed to such information.

Costs associated with *ra'ui*

The *ra'ui* have had minimal financial input. There was support by WWF Cook Islands for preparation of management plans and awareness activities, and from NZAID for signage/demarcation in the initial stages of the *ra'ui*. The business sector has also provided some support for the maintenance of the *ra'ui*. The Ministry of Marine Resources has undertaken periodic surveys of the *ra'ui* and the National Environment Service has been working with one community to develop legal support under the Environment Act. The *ra'ui* are managed by the Koutu Nui. However, as the Koutu Nui does not have funding, this management is done on a voluntary basis. In addition, the amount of attention devoted to the *ra'ui* is inconsistent due to the other commitments and projects of the Koutu Nui. Therefore, the operation and maintenance of the *ra'ui* currently rely on the goodwill of the community.

Integration of *ra'ui* into ICZM

It has been assumed that the decline in marine resources in recent decades is mainly the result of over-harvesting by the community. There has been insufficient attention to activities on the land, which have probably had at least an equal, if not greater effect on Rarotonga's lagoon. One drawback of the *ra'ui* system as it is currently practised is the lack of links to land-based activities. Recent health problems experienced in Rarotonga suggest that pollution on the land is having an impact on the lagoon, and the lack of an integrated approach to coastal management may be causing problems for the marine environment as well as affecting the health of local people.

In the Titikaveka area of Rarotonga, in 2003 and 2004, people swimming in the lagoon experienced a range of health problems, including a painful, burning sensation in the nose, running noses and sore, watery eyes, breathing difficulties, skin rashes and throat irritation. These problems also affected people on land who had not been swimming. Though the exact cause of the irritation has not yet been determined, it usually occurs after heavy rain and it is thought that it may be associated with pollution of inland areas that is being washed into the streams and down to the lagoon. The onshore breeze then causes some of the irritant to become airborne and blows it back, affecting people on the coastal fringe.

A number of initiatives have been taken recently to address these problems. For example, a project is underway to provide pig sewage digesters to pig farmers on Rarotonga in an effort to reduce pollution entering the streams and lagoons. The increase in tourism has led to a higher density of accommodation right on the coastline, leading to problems of sewage control. Almost all of Rarotonga's sewage is discharged through on-site septic tanks that consist of a single-chamber primary collection tank with an adjoining soakage cesspit. Research is currently underway to assess appropriate sewage systems for small tourism accommodation facilities. The Cook Islands Chamber of Commerce Environment Committee is compiling information in a bid to encourage accommodation providers to use better designed septic systems. Currently there are no specific regulations on the types of systems that must be used and septic tanks are not monitored by the Public Health Department, which is the responsible agency.

Conclusion

The recent use of *ra'ui* began well, but long-term enabling activities to ensure effective conservation measures appear to be less than adequate. There are a number of reasons for this — the most obvious being a lack of financial support to ensure dedicated and appropriate effort is expended on the *ra'ui*, where required. On the other hand, the more established PA in the outer islands seem less dependent on financial resources. This is partly because some of these PA are a considerable distance from the main island (e.g. Takutea, which is uninhabited) or are integrated into daily life as a matter of survival, as in Pukapuka.

Continued education and awareness is important to maintain support for the *ra'ui*. *Ra'ui* were well supported when intensive public education/awareness and community meetings were organised. This demonstrates that such activities must be maintained throughout the existence of a *ra'ui*.

Changes in customs have seen a shift in the way *ra'ui* are governed. For example, their importance in food conservation is less vital today than when society was largely subsistence based.

In the past, traditional leaders executed *ra'ui*. Now, the introduction of overriding legislation and new authorities for regulating PA, such as the Island Council and Environment Service, have weakened the authority of the Aronga Mana (traditional leaders) to effect *ra'ui*. The shift of power from the Aronga Mana to Government has displaced the power base of the traditional leaders.

The revival of *ra'ui* has restored some of the respect that previous generations had for their traditional leaders, and it is possible that this could be an important factor in getting community support for any expansion of PA into terrestrial areas on Rarotonga.

Lessons learnt

- In today's conditions, PA require financial input for long-term effective management.
- Gaining and increasing support for PA requires dedicated, continuous, and focused commitment to awareness and education activities.
- To avoid confusion over the roles and jurisdiction of various entities in relation to PA, in particular island councils and national government, awareness raising should not only remind people of the existence of *ra'ui* and their benefits, but should also publicise the roles of those concerned with the *ra'ui*.
- Management of lagoon areas alone may not be sufficient to solve all the problems. An integrated approach incorporating management of land-based activities that affect the lagoon is also needed.

Additional note

The Asian Development Bank is assisting the Cook Islands Government to develop an integrated system of regulations, bylaws and laws that together will provide institutional mechanisms for the effective and coordinated implementation of the Environment Act 2003 (TA 4273-COO: Legal and Institutional Strengthening of Environmental Management).

The focus will be on formulating appropriate regulations and bylaws to facilitate compliance and enforcement, and the review of legislation that may require amendments as a result of the enactment of the Act.

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Early effects of a community-based marine protected area on the food security of participating households

Pamela Weiant[1] and Shankar Aswani[2]

Abstract

There is general agreement among conservation practitioners that community-based marine protected areas (CB-MPAs) can improve food security in coastal communities. However, little attention has been given to how communities respond to CB-MPAs, particularly how households try to meet their livelihood needs following the establishment of a restrictive management regime. In this paper, we explore the early effects of a CB-MPA geared toward the management of marine resources harvested by women, as measured by perceived income and food availability. We strive to better understand (1) the contribution of women's fishing activities to livelihood needs, particularly the harvest of blood cockles (*Anadara granosa*) and mud clams (*Polymesoda* spp.) (the species under management); (2) differences in how households respond to a CB-MPA; and (3) the relationship between food security and certain aspects of reef health. To illustrate our case, we draw upon our research experience with social and biological impact assessments and our experience in establishing marine protection in the Western Solomon Islands.

Introduction

The use of community-based marine protected areas (CB-MPAs) for managing coastal marine resources has increased in recent years in many Pacific Island countries. These have had various degrees of success. CB-MPAs contrast with more conventional, top-down approaches to establishing marine protected areas in that they generally aim to incorporate the community and empower participants in the decision-making process. Community participation, however, has not assured the success of management programmes, and CB-MPAs have often failed socially (e.g. in terms of social equity and institutional endurance) and, concomitantly, have resulted in biological failure (e.g. in terms of fisheries management and biodiversity conservation). Social scientists working with MPAs have insisted on the need to focus on the intrinsic characteristics of communities and levels of project inputs (Christie et al. 2003; Mascia 2003) to understand why these management regimes succeed or fail.

Researchers are increasingly recognising that cultural and economic heterogeneity in community characteristics and participation often exists and determines the social and biological outcomes of introduced resource management regimes (Agrawal and Gibson 1999; Cooke et al. 2000; Kellert et al. 2000; Pomeroy et al. 2004; Pomeroy et al. 1997). An emerging area of social impact assessment in MPA studies is measuring how stakeholders share the economic costs and benefits following the implementation of a CB-MPA (e.g. Pollnac et al. 2001). To sharpen this focus, it is imperative to understand how household heterogeneity in productive activities promotes household well-being (i.e. food and livelihood security). Further, it is necessary to question the assumption that an improvement in biological resources (e.g. enhanced fish stocks) within a protected area will equally improve the well-being of all members of a participating community.

Food security is one measure of social well-being or the ability of households to access adequate food at all times and to meet their members' dietary requirements, by either self-production, purchase, gathering, exchange, or a combination of these (Baro 1996; Maxwell and Frankenberger 1992). This definition encompasses issues of food availability, accessibility, and consumption and reflects the household's decision-making and risk-taking processes regarding use and management of resources and assets (Davies 1996; Maxwell 1996; Negash and Niehof 2004). More generally, food security is an essential component of livelihood strategies, or a system in which assets (e.g. natural and financial resources, social capital, etc.),

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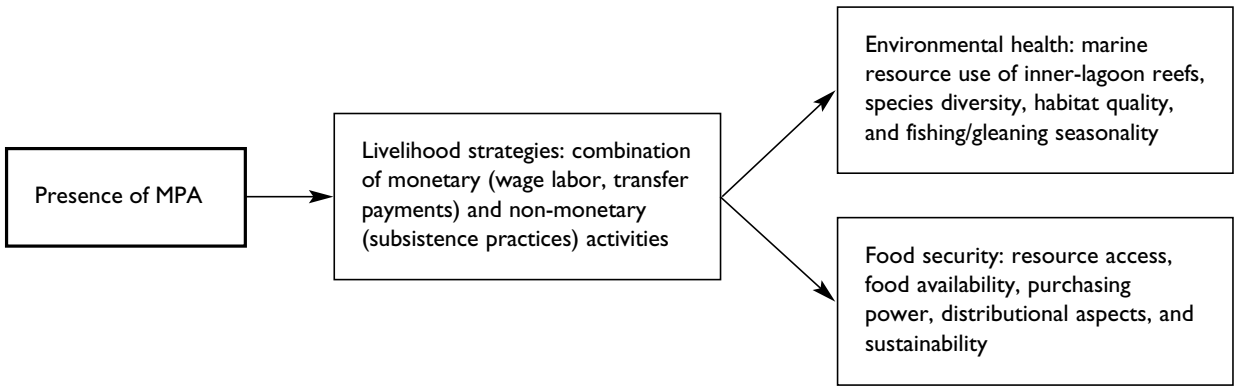

Figure 1. **Conceptual flowchart of livelihood strategies, food security, and marine resource health following the establishment of an MPA**

human activities (e.g. subsistence behaviour), and the accessibility of resources, as mediated by various governance institutions, influence the living conditions attained by a household (Chambers and Conway 1992; Davies 1996). Hence, asymmetries in people's assets and access to resources determine a household's ability to cope with shock, risks and stress induced either by external forces, such as the introduction of government-sponsored conservation measures, or internal ones, such as resource conflicts between people (Allison and Ellis 2001).

A CB-MPA is a type of governance institution that frequently affects household resource use patterns, although the impacts of changes on well-being are seldom quantified. In the case of development programmes that target agricultural production for subsistence farmers (Quandt and Ritenbaugh 1986), limited or enhanced access to resources or increased or decreased food yields (depending upon the biological outcomes of the management prescription) often disproportionately impact the food security of households within a community. These asymmetries clearly influence the overall environmental health of a given area, as households strive to meet their livelihood needs by using other resources or areas differently (e.g. more frequently). A change in habitat quality and species diversity, therefore, occurs not only within a reserve; it is also often the case that the spatial relocation of effort following the implementation of a management regime impacts environmental health outside the managed area. Therefore, it seems logical that we should conduct a dual analysis of social and biophysical dimensions when appraising the 'social' outcomes of a CB-MPA, particularly with regard to coastal communities that are dependent upon the health of the marine habitat for their overall well-being (Fig. 1) (Weiant 2005).

In this paper, we explore the early effect of marine resource management on food security by assessing households' responses to a CB-MPA. First, we ask about issues of household well-being and the contribution of women's fishing activities to household income and food supplies, and how a CB-MPA influences these factors generally. Second, we explore the relationship between food security and a CB-MPA. Third, we preliminarily explore some aspects of lagoon reef health outside the CB-MPA to develop an understanding of the spatial relocation of effort outside of the managed area. To illustrate our case, we present results of our first rapid social impact assessment (RSIA) (2001) of a CB-MPA established in Baraulu and Bulelavata villages in 1999, and we draw upon our experience in establishing marine protected areas in the Western Solomon Islands (Aswani and Hamilton 2004a, 2004b) (Fig. 2). In general, we argue that a community's overall well-being, as measured by income and food availability, can be improved through the establishment of CB-MPAs over the long term, as demonstrated by our most recent and comprehensive nutrition and health monitoring survey in the Roviana and Vonavona areas (2005) (Aswani and Furusawa, n.d). In this paper, however, we argue that the benefits afforded by the MPA can impact households differentially and may vary intra- and inter-annually. Such livelihood shifts not only affect people's well-being but also have the potential to have a detrimental effect on unprotected habitats.

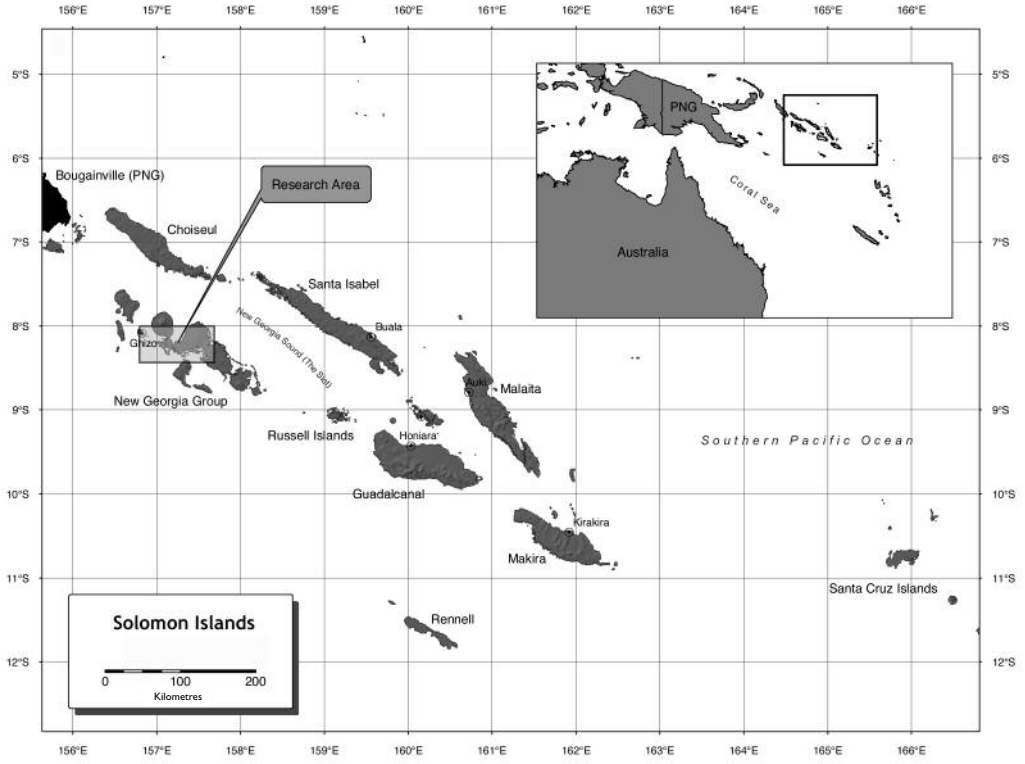

Figure 2. **Solomon Islands**

Study site

The villages of Baraulu and Bulelavata in the Roviana Lagoon, Western Solomon Islands, lie at the intersection of the Kalikoqu and Saikile chieftain districts (Fig. 3). The villages are formed by a single kin-related community and jointly have over 700 residents, a number of whom reside intermittently in the provincial and national capitals. Houses are single boarded with roofs made of sago palm or tin. In these homes, generations of families often live together and share the same kitchen. Household livelihood is semi-subsistence, with locals living off the land and sea while also generating cash from gardening, copra production, shell diving and remittances, among other activities. Fishing is vital for the livelihood of individual households and is of great cultural significance. Marine organisms provide the bulk of animal protein intake, and use of seafood in Roviana is similar to the national per capita consumption of between 32–40 kg a year (FAO 2002). Local leaders exercise control over their customary land and sea territories (customary sea tenure), although they share tenure rights with neighbouring villages (see Aswani 1999, 2005). In recent times, community-based governance has not assured the sustainable use of natural resources, and rising population and development pressures are increasingly hindering the livelihoods of women and children, in particular, their ability to harvest inner-lagoon invertebrate resources.

The harvest of shellfish is an activity typically conducted by women and children. Women predominantly glean in mangroves and in the outer barrier island intertidal flats. The mangrove bivalves collected include blood cockles (*Anadara granosa* and *A. antiquata*), mud clams (*Polymesoda* spp.), oysters (e.g. *Saccostrea cucullata*), Venus shells (*Gafrarium tumidum*) and mudwhelks (*Terebralia palustris*). The first three species are the most important economically and culturally. The growing perception that these species were being over-exploited encouraged Baraulu and Bulelavata community leaders to discuss the establishment of some sort of resource management programme in the late 1990s. With the assistance of the 'Roviana and Vonavona Marine Resource Management Programme' (established by Aswani in 1999), local leaders, including women representatives, decided upon the area and the conservation strategy that they thought would meet the needs of the women, the community and the marine resources.

The 'Baraulu and Bulelavata Women's Shellfish Project' was established in July 1999. It included a temporal and permanent closure designed to protect key invertebrate species. It also included a sewing component to simultaneously assist women to offset the income they would lose by not selling shells collected from the management areas. The bays of Duduli and Rereghana (Fig. 4) were closed to gleaning and fishing, particularly for the harvest of *Anadara granosa* (blood cockle,

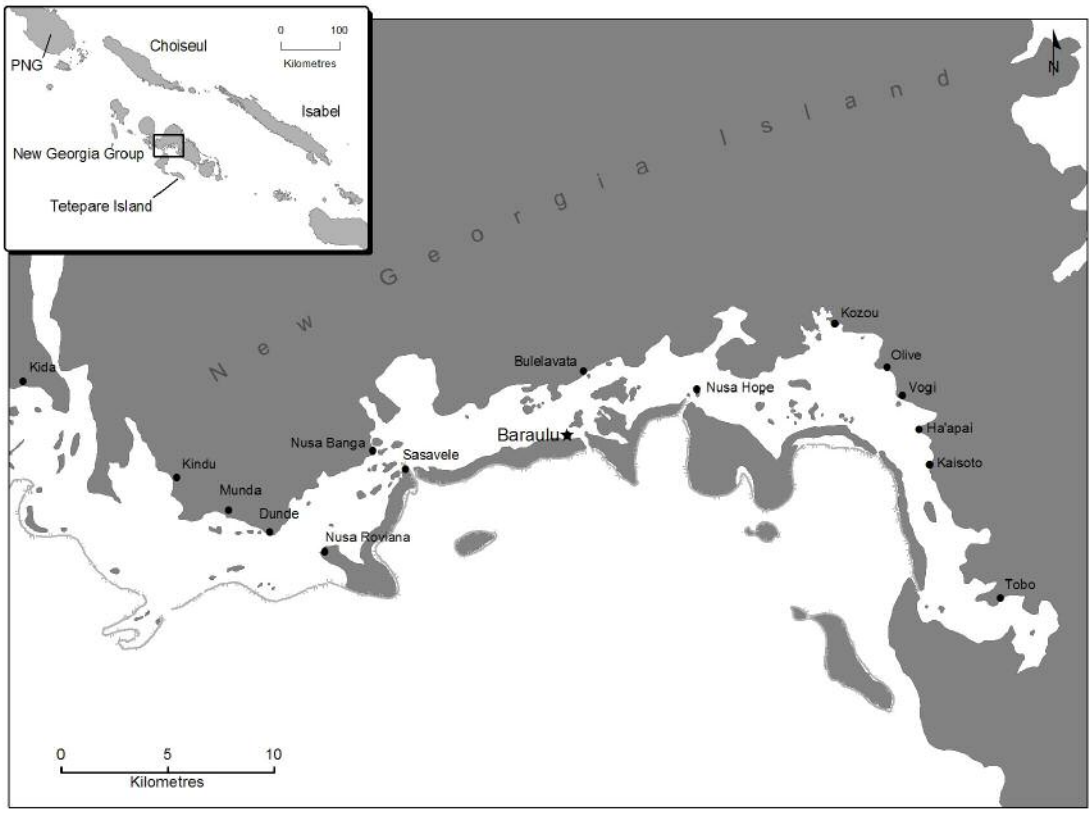

Figure 3. Roviana Lagoon

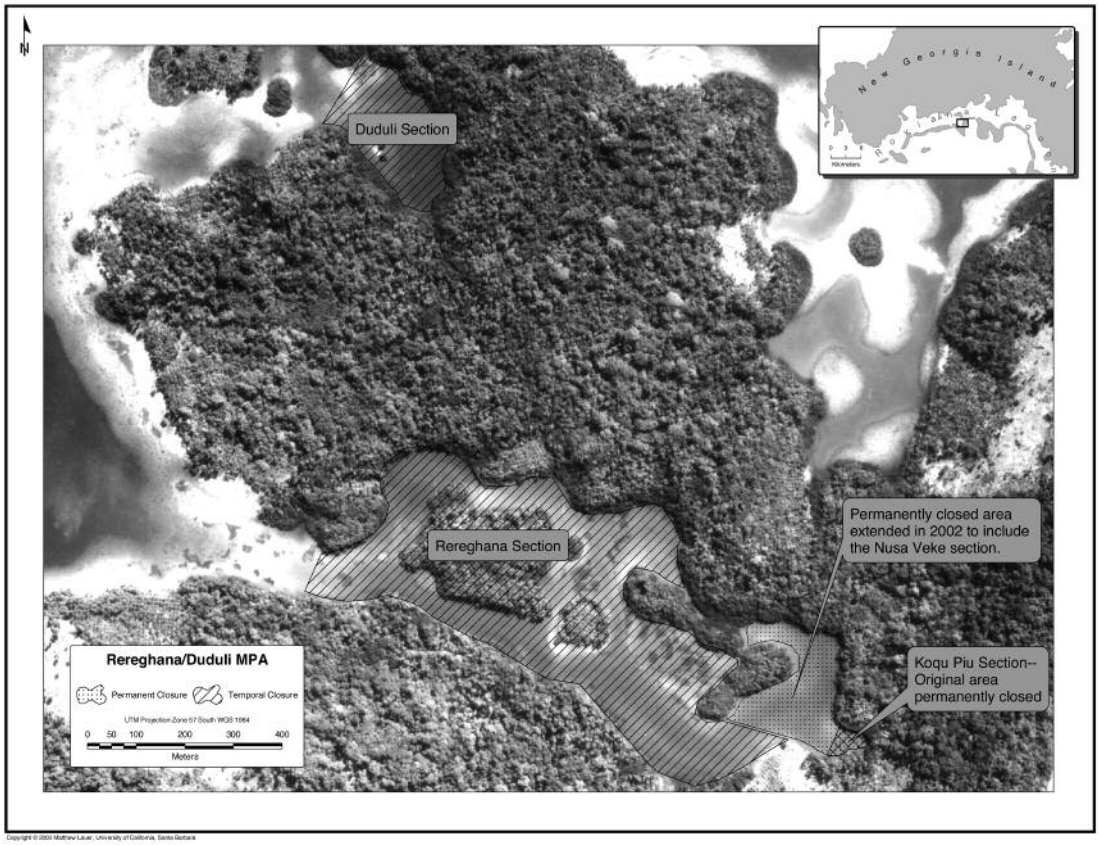

Figure 4. Rereghana and Duduli spatio-temporal community-based marine protected areas

locally referred to as *riki kosiri*) and *Polymesoda* spp. (mud clam, locally referred to as *deo*) shells. The bays were selected based on the perceived decrease in shell size and abundance that had resulted from fishing pressure, site preferences and proximity to villages. The management regime prohibits foraging for eight months (September–April) and opens the areas for four months (May–August) of each year.[3] Note that during the 'open' harvest season there are no limits on the take and this results in over-harvesting of *riki* and *deo*, thus potentially offsetting any increase in shellfish abundance that occurs when the area is closed. To counter this, local authorities have placed certain 'source' areas within the closures off-bounds permanently (locally referred to as *vetu moho* or 'clinics'). In general, the programme has been successful in sustaining the biological resources and in promoting strong community support (refer to Aswani and Weiant 2003, 2004 for further discussion).

Methods

A combination of qualitative and quantitative research methods was employed in the preliminary social impact assessment of the Baraulu and Bulelavata CB-MPA. Our aims were (1) to measure household dependence upon *riki*, *deo* and the other reef resources traditionally harvested by the women for household food security; (2) to assess how the newly established CB-MPA impacted the ability of households to secure food and income; and (3) to investigate how the CB-MPA may have initially affected ecological aspects of certain inner-lagoon habitats situated outside the managed area, especially those harvested by the women. We employed various interview techniques, food diaries and *in situ* inner-lagoon reef monitoring.

First, village households and their associated kitchens were drawn on a map to identify informants for interviewing. A systematic sampling design was employed to select a head woman from every third kitchen, and these women were then contacted for an interview. Note that the 'kitchen' was used as the sampling unit because kitchens are both single- and multi-family units within which all members share the responsibilities of providing and preparing food. We used structured and semi-structured interviews to elicit household data on (1) demographics, (2) economic strategies (e.g., income and time-allocation to productive activities), (3) food procurement strategies, (4) lagoon usage and knowledge, and (5) CB-MPA management issues. These questions were asked in reference to pre- and post-CB-MPA establishment and 'open' and 'closed' season intervals, since the goal was to understand changes in food security over time due to the management strategy. Second, food diaries were used to account for variation in the household's diet as a result of the management regime. Two one-week food diary schedules were distributed to the same kitchens, issued once when the CB-MPA was 'opened' and once when it was 'closed.' The food diary schedules were handed out at the beginning of the week for households to input the meals prepared. The data were then entered into a food matrix in which food items were tallied by household and compared.

Finally, we assessed the possible biological consequences of the spatial relocation of effort caused by the establishment of the CB-MPA.[4] We monitored certain aspects of the benthos and associated species in selected inner-lagoon reefs. The purpose of the monitoring was to collect biophysical data on habitats situated outside the designated protected areas in order to detect possible effects caused by shifting foraging patterns. The sampled sites were selected for monitoring based on the interview data on marine resource use and knowledge. Informants circled sites on maps, gave site names and ranked their preferred fishing areas during the 'closed' fishing season. The most frequently named sites were selected for monitoring. We employed a standard species identification scheme and a line-transect survey method, as detailed in the Reef Check Manual (Hodgson et al. 2003) for underwater research. The reef health of selected sites was assessed by observing species richness, habitat quality and other anthropogenic threats.

Species richness was documented in terms of presence or absence of fish, invertebrates, and substrates listed by Reef Check's Indo-Pacific List (Hodgson et al. 2003) (referred to as target key species) but modified to better reflect the local area. Target key fish species included butterfly fish (Chaetodontidae), sweetlips (Haemulidae), snapper (Lutjanidae), and parrotfish (Scaridae), and target key invertebrate species included diadema urchins, sea cucumber, and lobsters. To better reflect local resource use, locally important fish, invertebrates and crustaceans were also noted, with species that included *makoto noa* (titan triggerfish), *kakaha* (mangrove jack), and *pakopako* (anchor tuskfish), among others (referred to as target local species) (Table 1). Nine classes of substrate (e.g. hard coral, rock and

3. In recent years, the length of the open season has been shortened from 4 to 2–3 months.
4. Note that conclusions drawn from the ecological survey are only tentative in that we had no pre-CB-MPA ecological baseline data on the monitored sites for statistical comparison (before and after closure).

Table 1. **Monitored target and local species list (modified from Reef Check, 2003)**

	Common name	Scientific name	Local name
Fish species			
Target key	Bumphead parrotfish	*Bolbometopon muricatum*	*Kitakita* (juv)/*topa* (adult)
	Parrotfish (>20 cm) (various)	Scaridae	*Malakihi, birake, sinoku*
	Barramundi cod	*Cromileptes altivelis*	*Pazara horehoreqoqoro*
	Grouper (>30cm) (various)	Serranidae	*Pazara* (generic)
	Humphead wrasse	*Cheilinus undulatus*	*Habili*
	Wrasses	Labridae	*Sisiri*
	Snapper (various)	Lutjanidae	*Kakaha*, *heheoku*, *gasagasa*, *odongo*
	Sweetlips (various)	Haemulidae	*Pipirikoho*, *Pehu*
	Butterfly fish (generic)	Chaetodontidae	*Belkekere*
Target local	Thumbprint emperor	*Lethrinus harak*	*Osanga*
	Orange-striped emperor	*Lethrinus obsoletus*	*Ramusi*
	Blue-tail/mangrove mullets	*Valamugil seheli* and *Mugil* spp.	*Lipa*
	Coral breams (various)	*Scolopsis* spp.	*Dongopusi*
	Anchor tuskfish	*Choerodon anchorago*	*Pakopako*
	Titan triggerfish	*Balistoides viridescens*	*Makoto noa*
	Triggerfishes	Balistidae	*Kororo*, *kuluma*
	Blackbanded seaperch	*Lutjanus semicinctus*	*Kulele*
	Sabre squirrelfish	*Sargocentron spiniferum*	*Hori*
	Dash-dog goatfish	*Parupeneus barberinus*	*Pakao*
	Trevally (various)	Carangidae	*Mara* (generic)
	Orange-socket surgeonfish	*Acanthurus auranticavus*	*Tarasi*
	Damselfishes	Pomacentridae	*Kipa* (generic)
	Moon wrasse	*Thalassoma lunare*	*Solori*
	Box and puffer fishes (generic)	Ostraciidae and Tetraodontidae	*Poto patu*, *poto barata*
	Scorpionfishes (generic)	Scorpaenidae	*Kolohagege*
Invertebrates and other			
Target key	Diadema urchins	Diadema urchins	*Evaka*
	Pencil urchin	*Heterocentrotus mammilatus*	*Zore zanga zagna*
	Sea cucumber	Holothurians	*Puhaka* (generic)
	Painted rock lobster	*Panulirus versicolor*	*Hikama koqu*
Target local	Musk crab	*Thalamia crenata*	*Kalipete*
	Arch shell (sand)	*Anadara* spp.	*Riki repi ngohara*
	Arch shell (mud)	*Anadara granosa*	*Riki kosiri (riki)*
	Mud clam	*Polymesoda* spp.	*Deo*
	Mudwhelks	*Terebralia palustris*	*Ropi*
	Oyster	*Saccostrea cucullata*	*Roza*

sand) were monitored, as stated by Reef Check. The presence/ absence of six types of biotic cover were noted, including several Cymodoceaceae and Hydrocharitaceae sea grasses (e.g. *Enhalus acoroides*), coralline algae (e.g. *Halimeda macroloba*), macroalgae (e.g. *Caulerpa racemosa*), and sponge weeds (e.g. *Ceratodictyon spongiosum*). *Habitat quality* was assessed by examining reef damage, occurrence of disease (if identifiable) and presence of garbage/fishing lines. *Threat* was determined by identifying nearby land-based uses, proximity to village and boat use. Data were recorded in ACCESS, and sites were sorted based on the presence or absence of the biological parameters mentioned. Each site was treated as unique, and the sites were not compared, which provided preliminary baseline data for understanding current and future reef conditions.

Results

The Baraulu and Bulelavata livelihood system is no longer completely subsistence based. Nonetheless, household well-being is strongly linked to the exploitation of local marine resources, particularly the harvest by women of *riki*, *deo* and inner-lagoon reef fish, which proved to be critical resources for food and income.

General livelihoods and women

Interview data showed that women play a crucial role in securing income and food for their households and communities. They are largely responsible for child rearing and household duties (e.g. doing laundry, preparing meals and cleaning the house) as well as for tending gardens, harvesting marine resources and selling goods at the market (Table 2). Pre-CB-MPA time-allocation data showed that, on average, women spent more time gardening than men did and that young women spent as much time fishing and gleaning as their male counterparts (Table 3). Initial analysis of post-CB-MPA time-allocation data suggests a similar pattern to that existing before the establishment of the MPA (Aswani, unpublished data).

In general, women were responsible for harvesting marine resources in the inner lagoon areas (shellfish, crustaceans and reef fish). Women harvested *riki* in shallow bays by digging with their feet and hands and *deo* in mangrove forests by digging in the mud with their hands. Women also hand-lined for lagoon fish and gleaned in the inner- and outer-lagoon intertidal zones. While men foraged ubiquitously, they generally preferred to fish in the lagoon passage, outer-lagoon reef drops, and in open waters for pelagic and demersal fish, and to collect coconut crabs (*Birgus latro*) on the outer-lagoon seashore. Children harvested shells on the rocky, seaward side of the lagoon barrier islands (e.g. Turbinidae, *Nerites* spp. and chitons) and fished in the inner-lagoon shore with small handlines. Fishing behaviour, overall, is dictated by seasons, tides, wind, weather and lunar cycles. For instance, the best time to harvest *Nerites* spp. (*sise*) is during the full moon, and women prefer to harvest *riki* at low tide during and after rain.

General income patterns

Among Baraulu and Bulelavata households, there was diversity in economic strategies. In 2001, monetary income (all expressed as rounded percentages) was common among all households interviewed, including sales at local markets (90%), wage labour and/or remittances from at least one household member (60% regularly), gifts such as store food (40% regularly) and logging

Table 2. **Division of labor between males and females in Roviana Villages (Aswani 1997)**

Males	Females	Both
Clearing forest	Washing clothes	Cooking
House building	Washing plates	Child care
Making canoes	Sweeping	Collecting/chopping firewood
Making tools	Weaving mats	Fetching water
Carving	Weaving baskets	Planting crops
Hunting	Gathering *motu* leafs	Weeding and brushing gardens
Climbing coconut palms	Marketing produce	Harvesting crops
Climbing *Areca* palms	Gleaning for marine invertebrates	Picking nuts/fruits
Driving engine boat		Collecting *Pandanus*
Copra production		Collecting sago palm leafs
		Skinning coconuts
		Cooking copra
		Weaving sago for roofing
		Fishing
		Shell diving

Table 3. **Average number of weekly hours allocated to gardening and fishing/gleaning according to age and sex in Baraulu Village (Aswani 1997)**

Activity	7–16 years		17–26 years		27–45 years		46–75 years	
	Males	Females	Males	Females	Males	Females	Males	Females
Gardening	2.1	4.8	5.8	12.7	11.7	16.3	18.4	18.4
Fishing and gleaning	5.2	4.8	6.9	6.6	12.8	6.6	13.5	7.5

royalties (100% once or twice a year), among other activities. There was variation in types of employment, in which construction (20%), logging (20%), store ownership (15%) and teaching (15%) were the most common. Of these, 60% were permanent and 15% were temporary/seasonal jobs. Time-allocation and income-expenditure data have consistently shown since 1994 that gardening and marketing of food such as potatoes, eggplant, tomatoes, beans and bananas are of major importance for all households for accessing daily operational income (Aswani, unpublished data). Women sold most garden produce in Munda and at the Beulah Secondary School near Bulelavata on the New Georgia mainland. Fruits were marketed from the numerous orange and grapefruit trees surrounding the village. Less significant economic activities included weaving mats, house building, selling chickens, and diving for commercial shells. Income was used to buy household items such as soap, canned tuna, sugar and tea, and for church donations and schools fees. Some households saved up to buy iron water tanks, corrugated roofing and outboard motors, among other things.

Food security

Households had mixed preferences with regards to food procurement strategies, with half of the households eating equal amounts of store-bought and local foods and the others eating more locally harvested foods. In general, monetary income played a large role in food procurement. Rice, canned tuna, and noodles had prominent positions in the diet. Households largely purchased store food for taste, for convenience, and as symbols of purchasing power. For all households, the regular availability of rice and sweet potatoes allowed them to cope with periods of low food availability. Results showed that only 5% of the households sampled did not have sufficient food throughout the year and that such shortages often resulted from household size and available income. It was not unusual, however, for most households to experience occasional food supply shortages, often as a result of events that prevented women from tending their gardens and harvesting marine resources; such events included bad weather, religious festivals, a death in the community, community service days, or simply a lack of cash. In gardening, the ownership of plots (number, size and location) and access to a canoe (to travel to mainland gardens) dictated the type and extent of produce grown for each household. For fishing, households were able to access a number of inner- and outer-lagoon marine habitats year-round, and the limiting factor was access to a canoe and fishing gear, rather than access rights to marine resources.

Overall, households had few concerns about the quality of their diets or whether or not the CB-MPA was having an effect on their food consumption patterns. Based on the food diaries, households exhibited variation in types and frequency of foods prepared, particularly between the CB-MPA's 'open' and 'closed' periods. Regardless of season and household, rice and potatoes were consumed at least during one meal per day. Household meals ranged from basic (e.g. rice and tea for breakfast and dinner, as people do not generally eat 'lunch'), to more complex (e.g. tomatoes, *riki*, noodles, rice, and tea) meals. Households with food diet schedules that were less diverse and abundant tended to be economically disadvantaged as a result of household size (number of household members in the work force), sources of income and household composition (percentage of elderly or young children). The food diary results showed that during the CB-MPA's 'open' season, households generally prepared meals with more variety and protein than during the 'closed' season.

Significance of riki *and* deo *for household livelihoods*

The survey results showed that *riki* and *deo* were significant contributors to household food and income. Women explained that they often harvested *riki* and *deo* when the household was in need of food or income. Over 80% of households stated that these mollusks were 'very important' to their household diet and income. Over 90% of them harvested *riki* and *deo* year-round, and 75% of households sold these invertebrates at the market. Of the households sampled, over 60% sold these shells on a regular basis (≥3 times per week), and over 75% of them stated that their sale was 'important' or 'very important' to their household operational income. *Deo* was identified as the preferred species for selling in the market because it takes fewer shells to fill a palm-woven basket, due to this species' regular size.

Other marine resources harvested by women (e.g. shellfish, crustaceans and inner-lagoon fish) and men (e.g. outer-lagoon reef and pelagic fish) were sold at the market, but less often. We also found that the variation in significance of *riki* and *deo* to household diet and income reflected differing degrees of impact and coping strategies resulting from the CB-MPA. In particular, households that were larger in size, without babies and/or small children, that had regular wage employment, and that received gifts, were better off. This is attributed to greater diversification of livelihoods and, therefore, more abundant sources of food for household consumption.

Spatial relocation of effort

In regard to the relationship between food security and the invertebrate CB-MPA, 90% of households stated that they had more marine resources available during the seasonal opening of Duduli and Rereghana (Fig. 4). During the closed season, however, a change in the availability and use of marine resource occurred in a majority of households. Over 80% of households found it more difficult to collect *riki* and *deo* and thus to meet their household's dietary needs. Over 65% of households revealed that during the closed season, they harvested other inner-lagoon species from areas outside the project area more frequently. For example, one household harvested *riki repi ngohara* (*Anadara antiquata*) only during the closed season, while another harvested lagoon fish once or twice a week during the open season and four to five times per week during the closed season. While a majority of women (60%) believed that there were 'abundant' populations of *riki* and *deo* at Duduli and Rereghana as a result of the CB-MPA, they also recognised that many of the marine resources situated outside of the protected area are harvested more heavily during the closed season. Women also considered the state of other marine resources they harvested as 'not abundant' (e.g. *Anadara antiquata*, Turbinidae, *Nerites* spp. and chitons) or 'declining' (a number of lagoon fish species and *Saccostrea cucullata* oysters).

Women named 34 fishing locations that were preferred when the shellfish beds were 'closed.' The six sites most frequently mentioned for habitat quality and/or abundance of target resources (Kolekoleo, Miho Osanga, Sagauru Onone, Pakopako, Umabongi, and Tototu [Sagauru Onone is now under a permanent MPA]) (Fig. 5) are described in Table 4. The *in-situ* monitoring results showed that Miho Osanga and Onone, followed by Tototu, supported the greatest number and diversity of target key species, while Onone, followed by Tototu and Kolekoleo, had the greatest number and diversity of local species (Tables 5 and 6). The survey also revealed that the overall condition of the reef system at these six sites was poor, characterised largely by dead coral (rock), sand and rubble. At Umabongi, for instance, live and dead corals were covered in various macro- and filamentous algae and this also occurred at the other sites. Little anthropogenic damage was observed in terms of garbage and fishing lines. Some of these sites experience sustained boat traffic and human use and are in close proximity to several villages, which could explain the condition of the reef. In general, the findings show that all sites supported greater species richness and diversity of target local species than key species, which suggests that the inner-lagoon reef system remains important for household well-being, regardless of poor reef health.

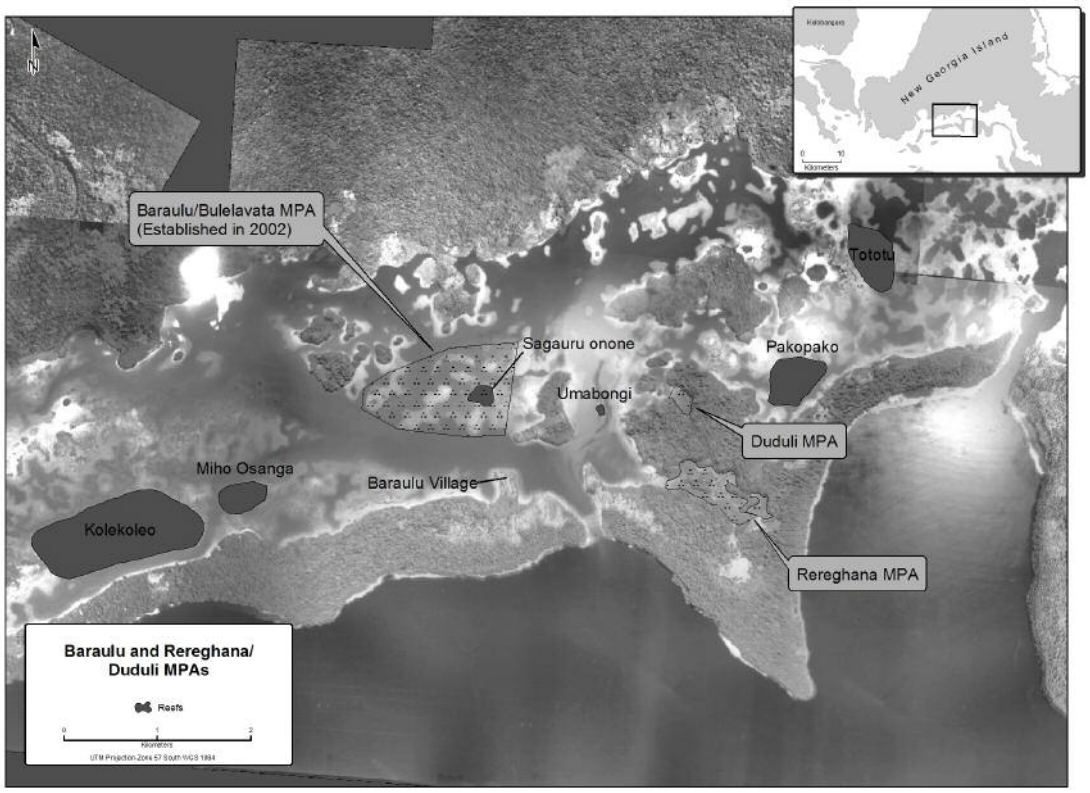

Figure 5. **Sites more often visited by Baraulu and Bulelavata women for fishing and gleaning (also the six monitored sites)**

Table 4. Resource and use characteristics of the six monitored sites (according to indigenous ecological knowledge)

Site name	Site rank	Resource harvested	Resource quality	Use /impacts	Overall human impact
Kolekoleo	**	Reef fish, ark shells (sand), and bêche-de-mer	Habitat quality: medium; fish abundance: high	Pollution from Sasavele; boat traffic; minimal poison fishing using *bunabuna* (piscicides); moderate harvest of invertebrates	Moderate
Miho Osanga	***	Reef fish, ark shells, and *Cardisoma* crabs	Habitat quality: high; fish abundance: high, large sized, arch shells (sand)	Motorized canoe highway; some poison fishing using *bunabuna* (piscicides) during low tide season (*masa rane*)	Low
Onone	*	Reef fish	Habitat quality: low; fish abundance: medium	Boat traffic, anchor dropping, fishing	Low
Pakopako	**	Reef fish, ark shells (mud), ark shells (sand), mud clams, oysters, and mud-whelks	Habitat quality: good but declining; fish abundance: high; shellfish abundance: high	Fished heavily by nearby villages: Nusa Hope, Bulelavata, Baraulu; net fishing; line fishing; anchor; walking; paddles; engines Increased use when Duduli/Rereghana beds are "closed"	Moderate
Umabongi	*	Reef fish and ark shells (sand)	Habitat quality: medium; fish abundance: medium-to-high; shellfish abundance: high, (sand arch shells)	Increased use when Duduli/Rereghana beds are "closed"	Low-to-moderate
Tototu	***	Reef fish, ark shells (sand), mud clams, oysters, and mud-whelks	Habitat quality: excellent; fish abundance: high; shellfish abundance: high	Motorized canoe —highway, and highly used fishing area; possible sewage from Nusa Hope, current dependent; net fishing; runoff from timber activities on mainland; increased use when Duduli/ Rereghana beds are "closed."	Moderate-to-high

* Intensity of visits to sites most frequently mentioned by women in terms of use and habitat quality.

Table 5. Summary inventory of fish and invertebrate species present at the six monitored sites

Biodiversity	Kolekoleo	Miho Osanga	Onone	Pakopako	Umabongi	Tototu
Fish						
Target key species						
Total number of species	13	6	16	10	5	6
Species richness †	23.2%	10.7%	28.6%	17.9%	8.9%	10.7%
Diversity ‡	42%	71%	71%	43%	15%	57%
Target local species						
Total number of species*	21	28	34	0	13	8
Species Richness	20.2%	26.9%	32.7%	0	12.5%	7.7%
Diversity	39%	33%	50%	0	44%	39%
Invertebrates						
Target key species						
Diadema urchin	0	0	0	0	3	0
Sea cucumber	0	0	0	0	0	1
Lobster	0	0	1	0	0	0
Other	-	-	-	-	-	**
Target local species						
Musk crab	++		+		++	
Ark shells (sand)		+			++	

† Species richness (relative measure of target species present): Total number of fish species at the site / Total number of fish species across all sites x 100 (all recorded key species)
‡ Species diversity: Number of target species at the site / Total number of species monitored x 100 (target key and local species).
* No minimum size criteria applied.
** Urchin resembling *Mespilia globulus* or *Tripneustes gratilla*.
+ = species present, ++ = species relatively "abundant," and +++ = species relatively "very abundant."

Table 6. **Substrates observed at the six monitored sites**

Biodiversity	Kolekoleo	Miho Osanga	Onone	Pakopako	Umabongi	Totoru
Substrate description[1]	Rock, rubble, sand, with some live and dead coral. Sea anemones present.	Rock and sand dominate. Abundant cover of sea grass and algae. Cabbage coral present.	Rock, sand, and very little live hard coral.	Mostly rubble, sand, rock, interspersed with hard, mostly dead, coral.	Rock, sand, and rubble. Most hard coral dead and covered in algae. Large areas covered by seagrass and algae.	Most hard coral is dead (rock) and covered with algae. Substantial presence of seagrass.
Coral						
Hard live coral	++	++		+		+
Cabbage coral		+				
Sponge			++			
Algae						
Halimeda macroloba		++	++		++	
Sea grass/macroalgae						
Cymodocea serrulata	++			+++		++
Enhalus acoroides	+	+			+	++
Halymenia durvillaei		+				
Caulerpa racemosa		++	++			
Ceratodictyon spongiosum	+	+				

1. Substrate class was based on Reef Check (2001): hard coral, soft coral, recently killed coral, rock, rubble, sand, silt, sponge, fleshy sea grass, and other. The categories of algae and sea grass were added to better document the local habitat.
+ = species present, ++ = species relatively "abundant," and +++ = species relatively "very abundant"

Discussion

The findings indicate that *riki* and *deo* are important for household food security, serving as important marine invertebrates for household consumption and sale at the market. In addition, the mollusks are important fall-back resources (as are rice and potatoes) that households exploit when food and income are scarce. Hence, the level of household livelihood has the potential to be diminished during the prescribed closures of shellfish beds. During this period, a diversity of livelihood strategies is of fundamental importance, and our results showed that households that were able to exploit other lagoon resources, could cultivate crops, or had access to a flow of monetary income were less impacted by the closures. In fact, households that had members working for wages or that received remittances from kin were better off during the closures than those that relied on subsistence resources overall.

Given these circumstances, how did women view the CB-MPA two years after its implementation? Involvement in the shellfish project had been high, with 60% of women involved in the planning and over 70% involved during monitoring between 2000 and 2003, which explains the large support for the project by women. About 75% of the women found that the populations of *riki* and *deo* in the project area were 'sufficient.' Further, according to other women, a range of benefits have been derived from the project including (1) the community's adoption of a conservation ethic, (2) easier access to *riki* and *deo* during the open season, (3) the perception that children will be better off in the future from conservation today, and (4), unlike other projects, the ability to address the issue of resources harvested by women (for further discussion see Aswani and Weiant 2004).

However, local opinions of the value of the spatio-temporal CB-MPA were mixed when respondents answered questions within the context of food and income. In terms of overall food security, 10% of women felt that food availability in their household had declined, about 65% that it had remained the same, and 25% that there had been some improvements. In addition, around 15% of households felt that their overall well-being had declined, 40% felt that it had remained the same, and around 45% felt that there had been a few improvements since the onset of the shellfish project. Drawbacks of the spatio-temporal CB-MPA voiced by households included (1) increased difficultly in meeting household needs when the shellfish beds were closed, (2) dissatisfaction with the diminished health of fishing grounds outside the

protected area, (3) uncontrolled harvest of *riki* and *deo* during the open season, and (4) an overall increase in competition over the shellfish harvest, as more women were selling *riki* and *deo* at the market than before the project started.

More generally, many households mentioned other factors that had negatively impacted their household income and food security. In particular, 45% of the households felt that the country's ethnic tension (1998–2003) had resulted in the loss of household income (remittances, wage labor income, and decreased sales at the market due to a decline in tourism) and that a change in household composition (return migration) had caused an increase in dependence upon local marine resources. In fact, the number of non-working individuals compared with working members (dependency ratio) increased between 1994 and 2001 (Fig. 6). A high birth rate (growth rate of 3% per annum) coupled with a change in the number of dependents may have exacerbated the degradation of neighboring reefs that were already being heavily used following the establishment of the spatio-temporal refugia in 1999.

Since the time of this assessment, the ethnic tension has ended (2003) and the CB-MPA programme has expanded across the Roviana and Vonavona lagoons. The CB-MPA programme now includes 21 MPAs (Aswani and Hamilton 2004b) — a majority of which are permanent 'no-take' marine reserves (Fig. 7) — and we are currently expanding the MPA network to other areas of the Western Solomon Islands. A new, permanent 'no take' MPA, which was established in Baraulu in 2002, covers an area of 103 hectares. As with other locations, the MPA site was chosen for its ecological and social importance using a combination of locally driven assessments (e.g. proximity to the village for monitoring and enforcement) and the information gained from our interdisciplinary research (see Aswani 2005; Aswani and Lauer 2006). We are confident of an increase in local support for the CB-MPA initiative because our 2005 social impact assessment (SIA) showed local support rates for the MPAs of between 70 and 90% in all regional villages.

In addition, our preliminary data analysis of a health and nutrition survey conducted in 2005 suggests that the MPAs are not having an adverse effect on health and food security and that, in fact, members of villages with effective MPAs have, on average, a greater intake of marine protein than those that do not. In terms of household food security asymmetries, our most recent survey found that dietary intake of marine-derived protein was slightly higher for males in larger households but not in smaller ones, even though this was only marginally significant ($p < 0.10$) (no differences detected for women and children). With regard to health status (i.e. body height and weight, body mass index or BMI, and body fat) there were no differences among adults (Aswani and Furusawa, n.d.). It is possible, then, that as economic conditions have improved in the Solomon Islands, and as the Baraulu and Bulelavata people have become accustomed to the CB-MPAs, the trend disfavouring certain households in terms of constant food availability has stabilised.

Finally, in terms of environmental health, our most recent survey indicated that for all habitat types no significant differences in substrate were observed between the newly protected reefs (2002) and unprotected zones. Damage, bleaching, and trash in coral reefs proved to be the same in protected and unprotected areas. In addition, the mean percentages of coral cover (all functional groups separately) on shallow reefs did not differ significantly from those on unprotected shallow

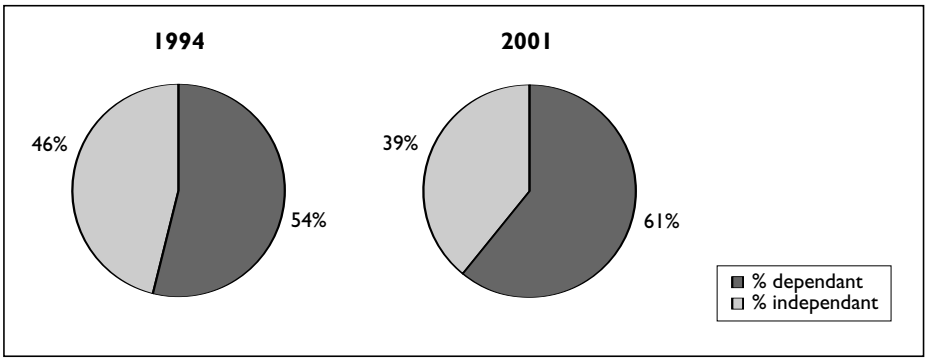

Figure 6. **Change in dependency ratio in Baraulu village between 1994 and 2001**

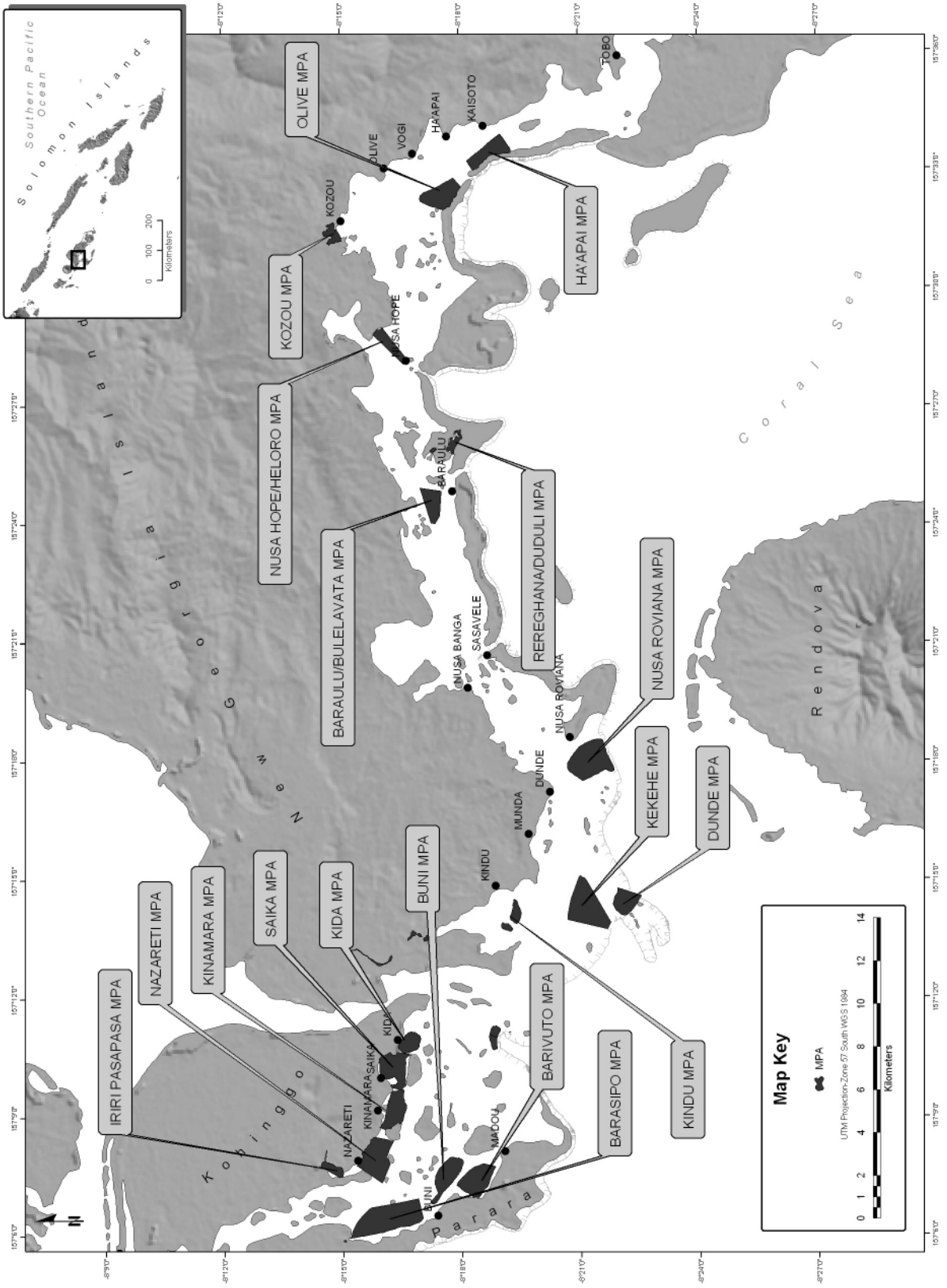

Figure 7. Roviana and Vonavona lagoons MPA system

reefs except for branching and encrusting corals, which were significantly more abundant on the protected mid-water reefs (Geelen, unpublished data). These results, among other factors, suggest that neighbouring sites were not being disproportionately degraded by human activities as a result of the MPAs.

In summary, the question of whether or not the implementation of the 1999 and 2002 CB-MPAs has had detrimental long-term environmental consequences for neighbouring reefs is still inconclusive. It is possible that during the initial stages following the implementation of the invertebrate CB-MPA in 1999 people readjusted their foraging strategies by placing more pressure on neighbouring reefs, thus leading to unexpected environmental deterioration (as suggested in this paper). However, as people became accustomed to the management regimes (both MPAs), they may have shifted or diversified their foraging strategies again. Anecdotal evidence suggests that many fishers are currently foraging at the boundary of the CB-MPA established in 2002. Fishers insist that the biological spillover effect of the MPA is leading to greater catches locally. Our first scientific monitoring (2004) showed that fish densities between MPA and non-MPA sites across Roviana were not significantly different, albeit fish tended to be larger inside the MPAs (Halpern et al. unpublished data). However, our most recent biological study (2006), in which we employed an underwater visual census in tandem with algal settlement tiles to asses the fish grazing intensity both within and outside the marine protected areas, suggests that the reefs within certain MPAs are characterised by greater fish diversity and higher biomass of fish (particularly grazing species), than the adjacent areas open to local fishing pressures (Aswani et al. unpublished data). Hence, it is too early to assess firmly whether local people's claims are accurate or not and whether or not the CB-MPAs are affecting neighbouring marine habitats negatively in the long-term.

Conclusion

This study shows how studying food security issues allowed us to better understand the impacts of the 1999 Duduli and Rereghana spatio-temporal refugia on participating households. We found that households responded and adapted to an introduced resource management regime differently. Our results verified that *riki*, *deo* and other inner-lagoon resources harvested by women are very important for the well-being of households and that they contribute significantly to their diet and income. The results also showed that to compensate for the decreased collection of shellfish during the temporal closures, activities varied with regard to how households used *riki* and *deo*. Some households appeared to trade-off the mollusks' value as sources of food and income, while other households opted to sell the mollusks rather than consuming them. The food security study hinted at ways in which some households were able to cope with and adapt to the shellfish harvest restrictions and were able to eat a healthy diet, obtain a decent standard of living, and experience less hardship than others, particularly during the initial years following the establishment of the first CB-MPA. This is an important finding, as women and the resources that they harvest are rarely integrated into management strategies.

CB-MPAs serve as one mediating process that governs the nature of resource extractive activities and access to resources. In the Baraulu and Bulelavata case, the spatial relocation of effort seems to have impacted areas outside the managed area, particularly during the CB-MPA's 'closed' season. As households strived to meet their dietary and income needs, they exploited other marine resources more frequently than before the shellfish project was established, and more during the closed periods than during the open periods. While the health of the preferred fishing areas of the inner-lagoon reef system appeared poor, both in terms of live coral and target fish species richness, these areas were of great importance to women. Causes of poor reef health may include overfishing, deforestation on the mainland and, to a lesser extent, sewage discharge from nearby villages. If the health of the inner-lagoon reef continues to decline, the populations of *riki* and *deo*, which appear to be doing well in the managed areas (Aswani and Weiant 2004), will become that much more important. Our management strategy should strive to better integrate the complete range of women's fishing practices to mitigate unnecessary trade-offs in the conservation of *riki* and *deo* and associated mangrove areas over other frequented inner-lagoon reef areas.

Studies of rural poverty diversification in marine-dependent communities are increasingly turning to livelihood system analysis to provide understanding of how diversification serves as a way to cope with variation and uncertainties in households' environments (e.g. Allison and Ellis 2001; Pollnac et al. 2001; Pomeroy et al. 1997). In this paper, we have argued similarly that social research on CB-MPAs must position the strategy as an event to which a household's livelihood system has to respond and adapt. We also suggest that more attention should be paid to the inter-relationships among social and biophysical processes in shaping livelihood systems of households and the environ-

mental health of their surrounding ecosystems when a CB-MPA is established.

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In contrast, this comprehensive and highly detailed study is based on a six-month field survey conducted jointly by the authors on the entire span of the fermented fish industry, from the catching of raw materials through processing to culinary uses and cultural-ecological contexts. The survey was conducted in Bangladesh, Cambodia, China, India, Indonesia, Japan, Korea, Malaysia, Myanmar, the Philippines, Taiwan, Thailand and Vietnam.

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