CRISP

Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique

COMPONENT 2B
Reef Restoration Project

PROJECT C2B1
Implementation of Reef Restoration Pilot sites

June 2007

BASELINE REPORT

FUNAFUTI ATOLL CORAL REEF RESTORATION PROJECT (Republic of TUVALU)

CRISP

Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique

SPREP/PROE

The CRISP programme is implemented as part of the policy developped by the Secretariat of the Pacific Regional Environment Programme for a contribution to conservation and sustainable development of coral reefs in the Pacific

The Initiative for the Protection and Management of Coral Reefs in the Pacific (CRISP), sponsored by France and prepared by the French Development Agency (AFD) as part of an inter-ministerial project from 2002 onwards, aims to develop a vision for the future of these unique eco-systems and the communities that depend on them and to introduce strategies and projects to conserve their biodiversity, while developing the economic and environmental services that they provide both locally and globally. Also, it is designed as a factor for integration between developed countries (Australia, New Zealand, Japan, USA), French overseas territories and Pacific Island developing countries.

The CRISP Programme comprises three major components, which are:

Component 1A: Integrated Coastal Management and watershed management
- 1A1: Marine biodiversity conservation planning
- 1A2: Marine Protected Areas
- 1A3: Institutional strengthening and networking
- 1A4: Integrated coastal reef zone and watershed management

Component 2: Development of Coral Ecosystems
- 2A: Knowledge, beneficial use and management of coral ecosytems
- 2B: Reef rehabilitation
- 2C: Development of active marine substances
- 2D: Development of regional data base (ReefBase Pacific)

Component 3: Programme Coordination and Development
- 3A: Capitalisation, value-adding and extension of CRISP Programme activities
- 3B: Coordination, promotion and development of CRISP Programme

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COMPONENT 2B
REEF REHABILITATION

■ **PROJET 2B-1 :**
Implementation of pilot sites (Fiji and Tuvalu)
■ **PROJET 2B-2:**
Edition of a Reef Restoration manual

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CRISP

Coral Reef Initiative for the South Pacific
Initiative Corail pour le Pacifique Sud

BASELINE REPORT
Funafuti Atoll Tuvalu

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1 Background

1.1 CRISP – TANGO Coral Reef Restoration Initiative

FSPI CCP program has recognized the need of applied research and capacity building to support community based activities. FSPI has been researching the development of low-tech coral reef restoration techniques as a viable management tool for local communities. FSPI, through its affiliates, PCDF and Solomon Island Development Trust, have conducted coral reef restoration trials in conjunction with the Darwin initiative project. The FSPI approach aims to be community based, low- tech, cost and management effective with a strong focus on active interest from communities and participation in awareness raising processes.

With funding support from the Coral Reef Initiative of the South Pacific (CRISP) with AFD as the financial partner, SPI INFRA and FSPI were nominated as technical and execution partners. Studies of reef restoration techniques are funded under the CRISP Component 2B: rehabilitation of ecosystems. The goal of this project is to establish and monitor two pilot restoration sites and to produce a technical manual on restoring coral ecosystems.

In conjunction with its Fiji affiliate, Partners and Community Development, FSPI and SPI Infra conducted a restoration trial in Moturiki, Fiji, from August 2005 to June 2006. A site in the Solomon Islands was proposed as a second pilot site, but the feasibility survey suggested that this choice was not appropriate for positive outcomes for the project. Consequently, FSPI received a request from their Tuvalu affiliate (TANGO) to conduct restoration trials on Funafuti Atoll. Following a scoping and assessment trip in November 2006 a pilot site was established in December 2006. This document reports on the establishment and first month monitoring results from the work in Tuvalu.

1.2 Funafuti Atoll Physical Setting

Tuvalu is a small low-lying atoll island nation with only 26 sq km of land area distributed among nine atoll island groups, with the land elevation generally less than 3m above sea. Tuvalu is spread over a large sea area with the furthest island, Nanumea over 445km from the capital, Funafuti. In contrast to its small land area, Tuvalu's territorial waters include a vast open-ocean area of 900,000 sq. km.

Subsistence fishing is an important aspect of Tuvaluan life, including in the government centre at Funafuti where alternative employment is available. The total national population of Tuvalu is very small, with approximately 11,000

people, and population growth rate is declining overall. However, Fongafale, the main island of Funafuti atoll, and location of the seat of government and most economic activity in the country, is becoming increasingly urbanized and is under severe population pressure. Due to limited employment opportunities on other islands, large numbers of outer island residents have migrated to Fongafale, which now has one of the highest population densities of any Pacific island. The increasing population on this island poses threats to the existing natural resource base of Funafuti atoll, especially its fragile coastal ecosystems and fisheries resources (Knapman et al. 2002; Lane 1993; Government of Tuvalu, 1992). It is believed that such threats exist due to direct increases in fishing pressure, and also due to environmental degradation associated with increasing nutrient and rubbish pollution of the lagoon from the burgeoning population center on Fongafale.

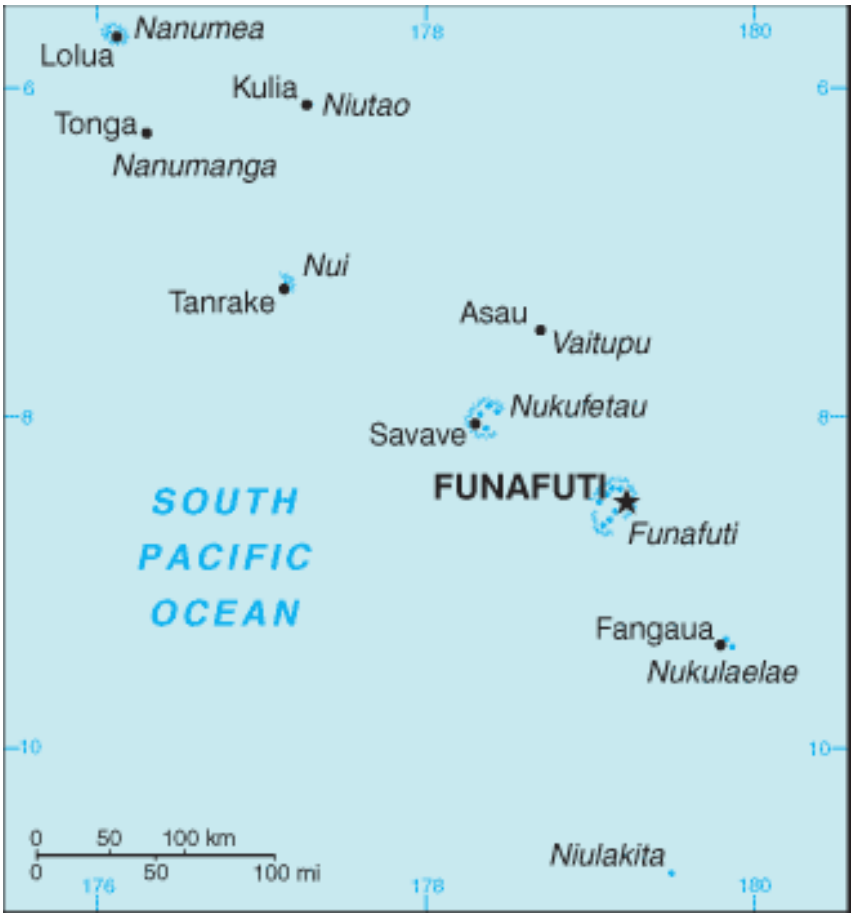

Figure 1. Map showing the Funafuti islands group and Funafuti atoll

1.3 Summary of Funafuti Conservation Initiatives by TANGO

The population of Funafuti is approximately 4,500, and is made up of community sectors representing the eight different islands of Tuvalu. The population lives almost entirely on one islet, Fongafale, and the population density is extremely high. There are 4 main districts on Fongafale,(*Lofeagai, Fakaifou, Funafuti and Vaiaku*) which were divided according to the 4 Tuvalu Christians congregation church that were establish on islet. Although everyone belongs to their individual island community they represent the district which they live in. The Funafuti district belongs to the native community people of Funafuti represented by two villages within this district, Alapi and Senala which are located in the centre of the island. Over the years, these two villages have been heavily involved and participated in many different educational awareness programs. These awareness programmes range from governance issues to environment issues such as water and environment conservation. Most of these programs were initiated by several regional programs such IWP, Disaster, Aids, women, to name a few.

A marine protected area (MPA) project called the Funafuti Conservation Area (FCA) was initiated in 1996 with support from the South Pacific Biodiversity Conservation Programme that was administered by South Pacific Regional Environment Programme (SPREP). The aim of the FCA was to conserve the terrestrial and marine biodiversity resources of Funafuti Atoll based on sustainable use principles, for the benefit of present and future generations. This includes the protection of valuable and productive habitats which contribute to the maintenance of biodiversity in the area; conservation of endangered species (such as turtles and giant clams); and improvement of the quality of fisheries resources. The specific objectives of the FCA project were to conduct a thorough public awareness campaign on marine, coral and island conservation; to develop capacity in relevant national institutions and to strengthen local and community capacity to manage the conservation area; to develop a sustainable resource management plan to be implemented and monitored by village communities; and to develop sustainable income generating activities for the Funafuti community and ensure sustainable financial support for conservation efforts. TANGO was the lead organization in all these activities.

The FCA encompasses some 33 sq km of ocean area in the western portion of Funafuti Lagoon, including six small islets or *motu* that occupy a total land area of approximately 8 ha. The boundaries of the conservation area have been defined at a line 50m seaward from the ocean side reef crest in the west, and to the 30m depth contour on the lagoon side in the east. In the north-south direction, the conservation area extends from just north of Tepuka Vilivili to just south of Tefala islets. The boundaries of the FCA encompass about 20 percent of the total coral reef area of the lagoon.

During the FCA project (5 years), implementation and intensive awareness building activities were conducted and were effective in improving local knowledge about conservation issues. However these activities have all been ceased since project ended in 2001. The FCA has been declared in the national legal framework, but needs further significant work on institutionalizing the FCA, with an obvious deficiency being the lack of an integrated community based management plan. Currently the communities lack awareness on the need for MPA's, and fisheries and government departments need funds for enforcement efforts and for more trained staff.

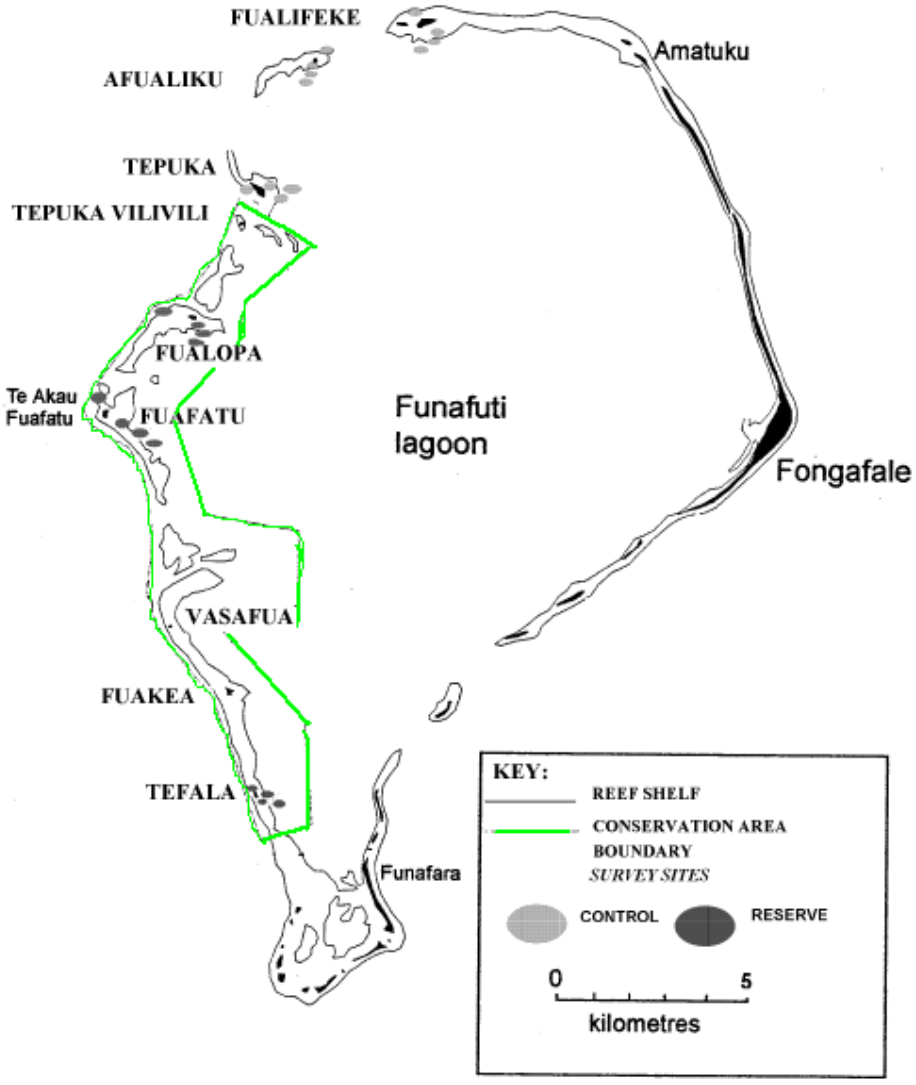

Figure 2. Funafuti Conservation area

FSPI, the Tuvalu affiliate, and Fisheries Department are assisting communities with coastal resource management initiatives by helping to establish MPA's as a management tool. The MPA project is also funded by CRISP, which is part of Component 1: Marine Protected Areas and Integrated Coastal Management. The MPA is used as a means for protecting threatened marine and coastal ecosystems and to allow for depleted breeding stocks of important food fish and invertebrates species to regenerate and reestablish. To implement the MPA initiative, Participatory Learning and Action Tools (PLA) are used with communities to engage and empower them to manage their own resources through highlighting the traditional systems of fisheries management as a basis for developing an effective management framework. Active community participation in planning and implementation, monitoring and enforcement, and awareness rising are all aspects of this project.

The FSPI Tuvalu affiliate, together with Fisheries Department support have an on going project of restocking clams in the fisheries monitoring area and there future plans are to support the community management plan by building capacity of local facilitators ,conduct socioeconomic survey on Fongafale, conduct PLA with Funafuti community ,held national community consultation and draft community management plan. This will be facilitated under CRISP MPA project.

1.4 Reef Restoration Techniques and Strategies

Reef restoration strategies can be broadly categorized into a number of techniques that are designed to:

1. Act directly on a degraded reef where the aim is to rebuild it to a similar level of structure, abundance, diversity and cover. An essential prerequisite is that the sources of the initial degradation are no longer present or acting in the area under consideration.
2. Enhance the natural recovery process, where physical or biological inhibitors to the recovery of a degraded reef are removed to allow natural process to work. These may include the removal of certain predators, improving water quality, the introduction of former species that have been removed or have died, and the physical alteration of the physical habitat so that recruitment and recovery will be accelerated above normal rates.

Additionally, these techniques can be used to create new reefs where previously there was none before. Artificial reefs built on a variety of solid platforms are created in this way. Also, a reef design is copied from similar natural examples that occur under similar conditions and habitats.

In many cases, biologically restore a degraded reef involves transplantation of healthy organisms (mainly corals) to increase coral cover and

enhance further natural recovery through higher recruitment rate. To ensure the best chance of success, there has to be a source of healthy transplant organisms present within practical distances of a restoration site, to minimize stress of transport and ensure that donor and receiver sites are quite similar habitats, particularly in terms of water depth, wave and current exposure, and physical-chemical conditions. Additionally, the reef ecosystem structure has to be the same in both restoration and source sites (same type of species and coral dominance in both sites).

Typical constraints in turning the theory into practice include:

- the need to complete the objectives in a cost-efficient manner, preferably using low technology approaches;
- the physical logistics of operating on a sufficiently large spatial scale to achieve the objectives;
- difficulties in dealing with the cause of the initial degradation that stimulated the need to attempt restoration;
- the need for regular ongoing maintenance and monitoring for the first few years at least after restoration is completed (which requires an adequate budget to complete this phase of the work);
- the difficulty of predicting unforeseen sources of disturbance that may not be present at a site before the initial restoration work is started. An assessment of some of the unforeseen disturbance factors can sometimes be done by undertaking a broad scale assessment of the current status of an area using a variety of indicators. The difficulty in predicting likely sources of future disturbance is often the most common reason for a lack of success in many similar projects;
- the many gaps in our current knowledge in reef ecosystem functioning and coral biology, which enable scientists and restoration practitioners to adopt techniques of restoration that would guarantee long term results. This links to the difficulty of predicting the behavior of coral transplants exposed to a variety of disturbances: this was the case in the first CRISP restoration experiment that we conducted in Moturiki Island, Fiji, where most of the transplants died 9 month after their transplantation due to a moderate bleaching event.

1.5 Status of Funafuti Atoll Lagoon Habitats 2006

The status of current reef communities and ecological conditions were assessed in a scoping visit to the atoll in October 2006 (Fisk et al, 2006). The viability of the full range of restoration strategies were assessed against the prevailing local physical conditions and the current status of reef resources. Proximity to a willing and interested local community with strong links to the

proposed site, and the logistical considerations relating to potential source and restoration sites, were also important factors in the overall scoping exercise. From this exercise, the main features present in the lagoon of Funafuti were:

- low densities of most reef fish guilds within the lagoon with the possible exception of the Funafuti Conservation Area;
- coral communities throughout the lagoon are overwhelmingly dominated by a number of branching *Acropora* spp;
- herbivorous grazing animals were very low in most locations; this included low densities of grazing fish species, with the apparent lack of grazing echinoderms (sea urchins in particular) was the most significant characteristic;
- the high densities of corallivorous gastropods (*Drupella cornus*[1]) throughout the lagoon, but in particular, in the eastern and north-western sectors, that were causing significant reductions in live coral cover;
- the very high abundance of macro algae in the same locations where there were high *Drupella* populations. The algae were competing with and overgrowing live coral in many places, and significantly occupying the spaces below branching live coral colonies. The most common algae species included: *Asparagopsis taxiformis*, *Caulerpa sertularoides*, *C.racemosa*, *Dictyota canaliculata*, *Enteromorpha* spp, *Halimeda* cf *gracilis*, *Microdictyon* cf *umbilicatum*, and *Padina sanctae-crucis*.

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[1] The prevalence of a different corallivorous gastropod (*Coralliophila radula*) in previous surveys (before 2003) was noted in Berdach (2003, quoting from Kaley 1997, Kaley et al 1999). This either represents a misdiagnosis or a shift in dominance of two different gastropod species.

2 Aims and objectives

2.1 General aim and objectives of the survey

The design and monitoring approaches of two different trials have been proposed from the scoping results. The two trials will be staggered approximately 9-10 months apart, with the first trial to be undertaken in November 2006, while the second trial is to be undertaken in approximately September 2007. The scope of work will be:

(1) Transplantation of branching *Acropora* to sand substrate areas adjoining the fringing reef adjacent to High School at Lofeagai.
(2) Transplantation of branching *Acropora* from within patch reefs near Funafala Island village in the southern end of the atoll.

The aim of the trials is to test, using low-technology restoration techniques, the viability and suitability of community based restoration efforts to improve the sustainability of small scale fisheries.

The objectives are:

- to increase awareness by communities of the importance of healthy reef habitats for sustainable fisheries;
- to assess the cost-benefits of engaging local communities to carry out low technology reef restoration efforts;
- to demonstrate that current disturbance factors (presence of high abundances of *Stegastes* spp territorial fish (possibly due to overfishing of predators), macro algae overgrowth, corallivorous gastropod infestations) are major contributors to the reduction in fringing reef fisheries biomass.

2.2 Specific aim and objectives

The aim of the first experiment is to create suitable juvenile fish habitat in an area that is currently low in fish and is threatened by *Drupella cornus* predation and macro algae overgrowth. One of the objectives is to demonstrate the response of the dominant branching *Acropora* to the removal of threats from *Drupella* and macro algae and to show that they are some of the obvious reasons for the decline in fish populations (aside from the high fishing pressure). The threats cause coral mortality, which in turn provides good substrate for the growth of macro algae. The macro algae can grow uncontrolled in this environment and frequently it completely occupies the good juvenile fish habitat that is normally present in the dead colony zone under stands of branching *Acropora.*

3 Site Selection and Justification

3.1 Site Selection

Lofeagai reef is situated north of the main township island of Fongafale (Figures 1, 2). A site approximately 165m from the lagoon side beach was selected in sandy substrate habitat adjacent to the fringing reef slope. The site is located in a sandy area 4-5 m deep, and is at least 30m distance from the fringing reef slope and other scattered patch reefs on the sand.

Figure 3. Map of Funafuti Atoll showing the scoping survey site numbers visited for the evaluation of potential restoration sites. The rectangle in the upper right hand side of the atoll is the approximate position of the established patch reef sites at Lofeagai.

Figure 4. Satellite image from Google Earth showing the approximate location of the four established patches at Lofeagai (gold circles; #1 to 4 are the patch reef numbers referred to in the text) and the location of the high school (gold rectangle). The scale on the right hand side of the compass represents 50 m length. Lengths refer to the distances between the reef features and individual patch reefs.

3.2 Justification

3.2.1 Biological and Logistical

Lagoon fringing and patch reefs in the vicinity of Fongafale Island have experienced heavy fishing pressure and other disturbances such as nutrient input from land, and are generally degraded, so the selected site is a good location for attempting a restoration project. There is abundant and healthy branching *Acropora* spp coral on the adjacent fringing reef slope that is suitable for transplanting to similar depths away from the slope in sandy areas. The trial

consisted of transplanting common and locally abundant branching *Acropora* spp (principally *Acropora nobilis* and *Acropora formosa*, with a low number of *Acropora grandis* colonies) from the fringing reef out to open sandy areas where a few similar naturally occurring coral patches are present. Another common species, *Acropora florida*, was not included in the trial as it was thought that fragments from this species do not adapt as well as the above species to living in sandy habitats. The latter species was also easily identified in the field and therefore could be left out of the transplant pool of species.

Logistical considerations were also pivotal in the decision on the location of the trial site. The major advantages with respect to logistical considerations include:

- Distance from shore to the site is accessible in all tide conditions, though low tides had the advantage of a shallower depth for free-diving to the coral patches,
- The site was protected from oceanic swells, but strong westerly winds can create turbulence and high suspended sediment loads on the inner west lagoon reefs making it hard to work at such times,
- Distance between the source and transplant areas was no more than approximately 30m,
- The transplantation could be carried out by divers using snorkeling gear,
- There was no requirement for boats or other costs, and,
- The location of the coral patches can be easily found using shore features.

3.2.2 Social and Community

Lofeagai is a Christian community of native Funafuti and outer island people who have a common goal in sharing and exchanging experiences and knowledge in developing a good community and healthy environment for all. Their main source of income is reef fishing and small scale pig farming. There are church, women, fisherman and youth groups in the community. The majority of the youth in the community attend Fetuvalu high school, which is one of two high schools on the Funafuti, along with the main government high school at Vaitupu. Religion plays an important role in binding everyone in the community. Most community members are Christians with only a few others belonging to other religions. From time to time, the pastor in charge of this community sets out programs for church activities, including youth social activities such as sports and feasts. Most fishers in this community concentrate on reef fisheries and majority of them are males. Old women go out to the reef when they are free of house activities, especially on Saturdays, where everyone enjoys time on the reef. Spearfishing, net fishing, and line fishing (either by hand or rod) are mainly done by youth groups. Fishermen with outboard engine boats, go outside the lagoon to the open water to catch tuna or mackerel to sell at the main markets. Sometimes

during new moon periods, they catch flying fish which they sell to support their needs such as electricity, fuel, and even school fees for their children.

There is a relatively high awareness by the community of the Funafuti Conservation Area (MPA) on the western side of the atoll (Berdach, 2003). The FCA project was established in 1996 and operated until 2001 as part of the SPBC Program based at SPREP, Samoa (SPREP, May 1993). The aim of the project was to conserve the terrestrial and marine biodiversity resources of Funafuti Atoll by protecting valuable and productive habitats which contribute to the maintenance of biodiversity in the area, the conservation of endangered species (such as turtles and giant clams), and improvement in the quality of fisheries resources. One of the objectives of the current restoration project is to improve fisheries resources and to increase community awareness of the need for healthy reef habitat for sustainable fisheries. So this project hoped to build on the already existing degree of awareness of the need for healthy reef habitat for continuation of the benefits from sustainable fisheries resources.

The Lofeagai community has seen a decline in their fish harvest and an increase in fishing effort, which prompted a request for advice and assistance through their church to TANGO. TANGO discussed the request with fisheries and community youth groups as the target implementation group. At the same time, engagement with this community was seen as an opportunity to conduct a public awareness campaign on reef conservation and community management. It was also hoped that support would be given to an environmental conservation program that would be developed in Fetuvalu School to educate the younger generation on the need for protection and wise management of coral reefs.

A major reason for selecting this site is that it would offer high community exposure to the project as it is located on their lagoon reef. As well, surveillance could be maintained by the local community to ensure no interference while the project is developing, and school awareness programs could include demonstration visits to the site as part of awareness raising.

4 Methods

4.1 Experimental Design

Small scale restoration techniques that are adapted to local ecological conditions were employed to assess the feasibility of intervention as a management tool for sustainable fisheries management.

The newly created coral patches on sandy substrate were composed of branching *Acropora* spp sourced from adjacent fringing coral reef areas where abundant live coral is present. Donor *Acropora* spp branching coral colonies were readily available in similar depth water on or at the base of many of the patch reefs and fringing reef areas. The choice of donor colonies was restricted to the lower slope with the aim of minimizing the relative depth between donor and restoration positions. Approximately 20% of each donor colony was used to minimize the impact on individual donor colonies.

Although it is preferable to adopt a trial design that includes 'before - after' as well as 'control - treatment' factors, it was not possible to have identical 'control' sites present for this purpose. In the case of the sand based patch reefs, identical control sites would have to be naturally occurring patch reefs located in an identical habitat to the restored patches. Each of the replicate patch reefs would also have to be composed of a similar mix of coral species, and be of similar shape and size as the restored patch reefs. This situation was not present at the chosen trial site, so it was decided to have a monitoring design that only included a ‘before – after’ study.

The limitation in having only 'before - after' surveys of restoration sites is that there is no way of accounting for seasonal and other natural changes in fish populations within the patches. The presence and trends over time in fish populations in and around newly created coral patches is the only way of demonstrating the effectiveness of a healthy habitat.

The location of the experimental site is opposite the Fetuvalu Secondary High School at Lofeagai, which is north of the business centre of Funafuti on Fongafale Island. Four elliptical to circular patches of 3-4m diameter were established on sand areas that are isolated from the main fringing reef by an average distance of 30m. Care was taken to have no other patch reefs within 30m of the trial patch reefs so that resident fish in the naturally occurring reef patches would not readily include the new patches in their home territories or forage range. With the above restrictions, it was possible to establish 4 patches in 2 pairs of 2 patches approximately 45m apart, with each of the patches within a pair located approximately 12m apart. The four patches were at the same depth of 5m.

4.2 Transplantation Protocols

Donor colonies were collected for each of the two sets of patches from the adjacent fringing reef with care taken to not over collect from any single colony or area within the reef. The aim was to achieve this without collecting more than a maximum of 10% of a colony and no more than 20% of colonies from each area. Donor colonies of branching *Acropora* spp were collected from the mid to lower slope of the near shore fringing reef, cleaned of macro algae and *Drupella cornus* individuals at the donor site, and carried in the water by divers to the restoration patch reef site immediately off shore (towards the lagoon centre) from the donor site. The coral communities at the main collection sites were in only moderately healthy condition with approximately equal percent cover of live and dead coral, due to active *Drupella cornus* and high macro algae overgrowth. The live coral cover (22% to 32%, see Results) was in good health and did not show signs of stress or disturbance, i.e., from bleaching or disease.

Divers were instructed to carry only one individual donor colony in each hand if they had two colonies ready for transplanting, so that no abrasion occurred between the colonies during their transportation. The colonies were held by their base, which was often dead, so as to minimize tissue damage to the live portions of the colonies and to minimize damage to the growing branch tips. At the donor site, colonies were carefully placed in an upright position on or in the sand substrate. The colonies were carried to the bottom substrate and not left to fall to the bottom from the surface, so as to avoid damage to the colony branches.

The circumference of each new patch was marked in the sand and colonies gradually built up within the circle until less than 20cm space was present between the most of colonies. The most competent divers spent some time at the new patches to adjust individual colonies, and if necessary, partially bury all colonies in a patch so that they were properly positioned. Care was also taken to ensure the colonies were positioned in their normal upright growth position.

4.3 Effect of Colony Removal on Donor Site

The effect on donor site of the removal of colony fragments for the creation of new patch reefs on sand substrate were estimated using photo analysis of before and after the transplantation is completed. The standard photo distance was approximately 2m from the reef and the photos were taken at a slightly oblique angle to the reef slope. Percent live coral cover estimates of the mid to lower slope were carried out using a random point freeware program called CPCe (Kohler and Gill, 2006). Five photos from each of 2 major donor sites were taken before and after the transplantation work was completed. The

two sets of 5 photos represent the donor areas adjacent to the two pairs of patch reefs, i.e., Donor Site 1 was opposite patches 1 and 2, and Donor Site 2 was opposite patches 3 and 4. Each photo was analyzed by categorizing the benthos underneath 10 random points within each photo. Benthic categories from the 50 random points analyzed from each site were used to estimate percent cover.

Branching *Acropora* spp colonies were collected from the adjacent fringing reef habitat with the requirement of collecting from the lower to mid slope which was in 3-4m depth at low tide. Probably as many as 4-5 species of *Acropora* were used in the experiment and no estimate of the relative numbers of each species that comprised the patches were recorded. However, the relatively more abundant species were most likely more representative in the patch reefs.

4.4 Effort Analysis

For each activity phase (design, collection, movement, transplantation, baseline monitoring, and maintenance), a record was kept of the amount of time and personnel involved in carrying out the designated activities in order to conduct costs and effort analyses for comparison with other studies. Factors relating to the effort involved in establishing the trials include:

- the time spent for each activity,
- the number of people involved for each activity,
- the monetary costs to undertake these activities (salaries, materials, overheads).

The **design** of the trial site included time spent on survey and reconnaissance and discussions with local counterparts. Field assessments included the time spent on broad scale assessments as well as time spent on fine scale assessment once a general area was thought to fulfill all the selection criteria. The design phase also includes time spent on outlining a work plan and best practice approach, designing monitoring data sheets, and the training of local counterparts in transplantation and monitoring activities.

The **transplantation** phase of the work included the collection and cleaning of colonies at the donor site, the movement via swimming of colonies to the new patches, and the placement of colonies in the new patch reefs. Careful placement of colonies on and in the substrate was an important activity that averaged approximately 15% of the total ‘transplant’ time.

The initial **baseline monitoring** phase included the measurement of patch reef dimensions, including live and dead coral volume measurements. The measurements involve the use of 1m length measuring rulers. **Ongoing monitoring** of the patch reefs include the repeated coral volume measurements in addition to recording coral health indices and fish numbers, types, and sizes.

The presence of other organisms such as macro invertebrates within the patches are also to be recorded.

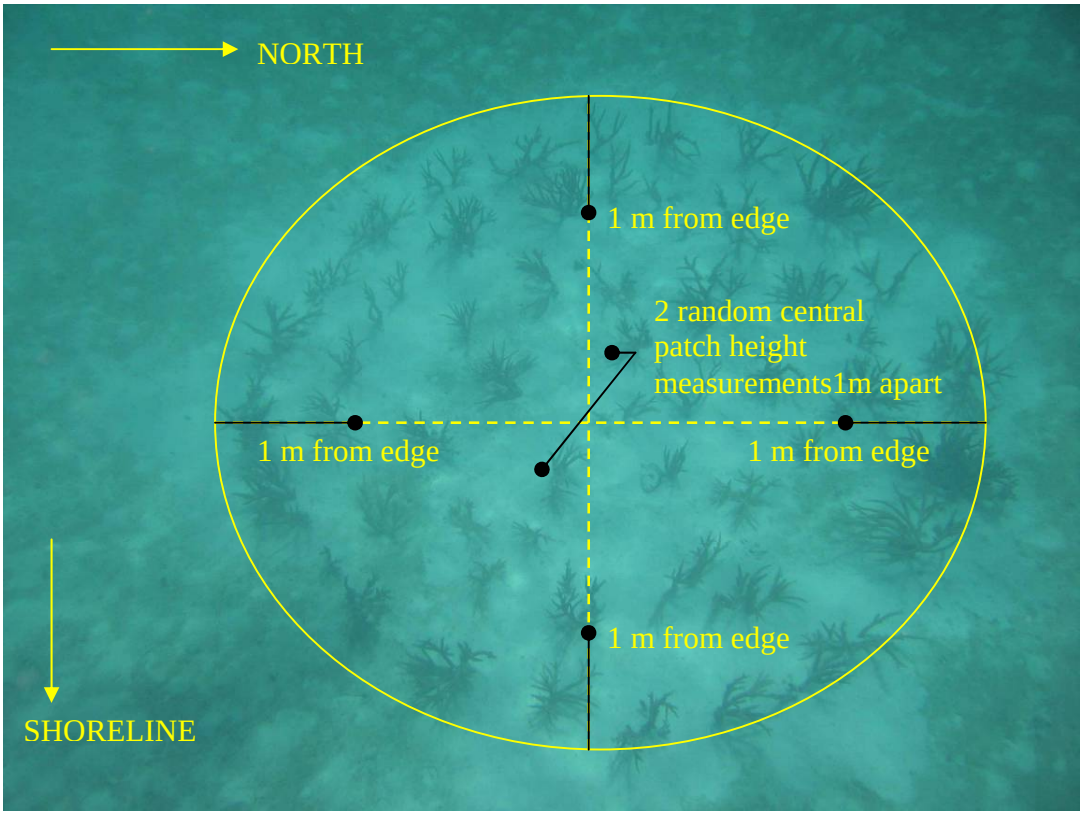
Maintenance of the new patches will be carried out to remove the potential impacts from macro algae and predation from *Drupella cornus.* In addition, it was decided that any territorial damsel fish (*Stegastes* spp) that become established in the new patches are to be removed using small spear guns. The damsel fish aggressively expel all other herbivorous fish from their territories, and may be an additional cause of low juvenile and young adult fish habitat, leading to reductions in fish biomass. It is proposed that for the first 2 months, a maximum of 2 weeks between visits be adopted for maintenance purposes, after this time the effort compared to its effectiveness can be reviewed, and the frequency of maintenance visits either reduced or increased. This will have to be done by local counterparts, and the time spent and number of personnel involved is recorded to estimate the amount of effort required to achieve a successful outcome.

4.5 Transplanted Patch Reef Monitoring Methodology

Monitoring of changes in the patch reefs will be carried out for a period of 18 months from the initial establishment time. The initial patch reefs (four in total) were first monitored the day after completion of transplantation of corals, on the 24th November 2006. This first monitoring established the baseline data for coral, fish, health, and disturbance indices. The monitoring schedule is set out in the work plan (Table 4). It is proposed that regular standardized monitoring will be carried out 1-month, 3-months, 6-months, (if necessary) 9-months, 12-months and 18-months after the baseline monitoring date.

4.5.1 Corals

The condition of transplants will be monitored using the following health indices: growth of patch reef coral, coral mortality, and incidence of bleaching or diseases. Disturbance indices will record incidences of predation by *Drupella* spp and crown of thorns starfish (COTS). The occurrence of macro algae within the patch reefs will also be monitored as a disturbance factor.



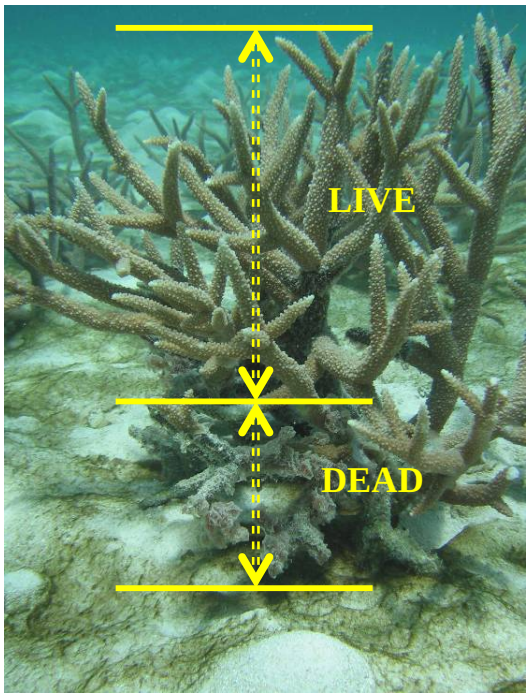


Figure 5. Photo illustrations of essential measurements to be taken as part of the monitoring protocol (Top: patch reef measurements used to calculate the volume of coral; Bottom: individual measurements for live – dead coral portions.

GROWTH RATE

Growth of transplant coral will be followed by measuring the volume of live and dead coral, and the overall size of each of the transplant patches. The importance of monitoring the volume of each patch is to assess the success of transplantation and the availability of fish habitat over time. It is important to measure both live and dead portions of a patch as fish use the patches for shelter (both the live and dead portions, with the live portion providing an increasing volume of protective area over time), and for food (herbivores graze on turf algae that grows on the dead portions). The method of measuring the volume of coral patches requires an adjustment of the volume estimates where a portion of the corals in a patch might have completely died. In this situation, a visual estimate of the percentage of completely dead coral is deducted from the estimate of the volume of live coral.

Live and dead coral volume of each patch is estimated using the following measurements:

- **maximum (Dmax) and minimum (Dmin) linear diameter** of each patch, using a standardized approach of measuring the diameter axes of first, the diameter in a direction that is perpendicular to the shoreline (or from shoreline out to the mid lagoon), and a diameter at right angle to the first diameter that is generally parallel to the shoreline;
- **height** above the substrate of the dead colony zone ($\mathbf{H_{D\ (1\text{-}6)}}$) and the height from the substrate to the outer most coral branch ($\mathbf{H_{T\ (1\text{-}6)}}$) in that position (the live coral zone is calculated by subtracting the dead coral height from the total height at that position, ie, $\mathbf{H_{L(1\text{-}6)} = HT_{\ (1\text{-}6)} - H_{D\ (1\text{-}6)}}$;
- the **volume of live and dead zones** in a patch is calculated using a standard number of 6 height measurements scattered around the coral patch (the standard approach is to measure 4 positions within each patch that are approximately in the vicinity of a meter in from the edge of the two max/min diameter positions, and an additional 2 positions approximately a meter apart in the central zone of the patch).

The volume calculations for each patch are as follows:

Mean Radius ($\mathbf{R_M}$) of patch	**(Dmax + Dmin)/2**
Total Area ($\mathbf{A_T}$) of patch	$\mathbf{\Pi\ (R_M)^2 = 3.142\ (R_M)^2}$
Mean Total Height $\mathbf{H_{TM}}$	$\mathbf{\sum H_{T\ (1\text{-}6)}\ ) / 6}$
Mean Dead Height $\mathbf{H_{DM}}$	$\mathbf{\sum H_{D\ (1\text{-}6)}\ ) / 6}$
Mean Live Height $\mathbf{H_{LM}}$	$\mathbf{\sum H_{L\ (1\text{-}6)}\ ) / 6}$
Total volume of patch ($\mathbf{V_T}$)	$\mathbf{A_T\ x\ H_{TM}}$
Volume Dead Coral ($\mathbf{V_D}$)	$\mathbf{A_T\ x\ H_{DM}}$
Volume Live Coral ($\mathbf{V_L}$)	$\mathbf{A_T\ x\ H_{LM}}$

BLEACHING INDEX

The presence of bleaching (% bleached, degree of bleaching) is recorded each monitoring time using the following categories:

- percent of the total patch with any of the below bleached categories present (several species of *Acropora* spp compose each patch so there may be differential responses to bleaching that should be noted); and,
- bleaching categories – none, slight (paler than normal colour), partial (upper surfaces white, lower surfaces normal), major (all surfaces white or very pale).

If coral disease symptoms are present in the patch corals, this will be described and the percentage of the total patch with symptoms noted. Photos will be taken for verification of the symptoms.

MACRO-ALGAE COLONIZATION

Macro algae colonization similar to the adjacent fringing reef is likely at some stage over the total monitoring period. The monitoring protocol for macro algae includes an estimate of the relative amount of algae present each monitoring period using the following categories: none, low, medium, high. The high macro algae category should be comparable to what is currently present in the adjacent fringing reef, under branching *Acropora* spp colonies, and the lower abundance categories relatively less than the high category. Macro algae is required to be cleaned from the coral during each monitoring time (and recorded that it has been done, see 3.4. Effort Analyses), as it is thought that the algae can take over the lower dead coral zone to the detriment of shelter and feeding habitat for fish. If this cleaning schedule is not sufficient to keep the patches clean of macro algae, a more regular maintenance schedule will have to be adopted.

OTHER DISTURBANCES

Disturbance indicators are to be recorded each monitoring period which include the presence of *Drupella* gastropods and the number of individuals that are removed to the adjacent fringing reef (or destroyed). The size of gastropods should be recorded by measuring each gastropod along the longest axis. Similarly, crown of thorns starfish (COTS) that may be present in the patches should be carefully removed and destroyed, and the maximum diameter of each one recorded.

4.5.2 Fish

The fish monitoring data are separated into fish found in or within a few meters of each of the patches. Fish abundances will be monitored using the number of each major trophic fish group and dominant plus sub-dominant species / families, along with individual sizes grouped into five size classes:

<5cm (median = 2.5 cm)	= middle finger tip to first finger joint
6-10cm (median = 7.5 cm)	= middle finger tip to knuckle
11-20cm (median = 15 cm)	= middle finger tip to wrist
20-45cm (median = 22.5 cm)	= middle finger tip to elbow
46-65cm (nominal value of 55 cm)	= middle finger tip to elbow length

The size classes correspond to the commonly used local description of fish sizes that compare lengths of finger tips to various hand and arm joints. The mid point (or median value) size of each of the fish size category ranges are used as an approximate estimate of the size of fish for describing and graphing fish size data.

Experienced fish observers will carry out all fish surveys, and all are from the Fisheries or TANGO organizations on Funafuti. It is anticipated that as the project progresses, interested and experienced volunteers from the village and local high school will participate in the surveys under the supervision of the current monitoring team. During community monitoring, errors in fish size estimation and identification can often occur. To minimize observer errors in estimating fish sizes, it is proposed that small size categories are used rather than actual length estimates. To minimize observer errors in fish identification, it is proposed to focus on higher level classification categories of fish identification (such as Family level) with records taken of the dominant species present within these families. Fish surveys should be of each of the new patch reefs that includes an immediate area around each patch (to a distance of 5m).

The potential range of fish species that would be expected to be encountered on the patch reefs are listed in Table 1 below. This represents a preliminary list and may not reflect the actual local fish communities normally encountered on Funafuti.

Family	Common Name	Family	Common Name
CARCHARHINIDAE	Requiem sharks	POMACENTRIDAE	Damselfishes
DASYATIDAE	Stingrays		Sergeantfishes
MURAENIDAE	Moray eels		Anemonefishes
OPHICHTHIDAE	Snake eels		Farmer fish
PLOTOSIDAE	Eel catfishes	LABRIDAE	Wrasses
SYNODONTIDAE	Lizardfishes	SCARIDAE	Parrotfishes
HOLOCENTRIDAE	Soldierfishes	SPHYRAENIDAE	Barracudas
	Squirrelfishes	MUGILIDAE	Mullets
AULOSTOMIDAE	Trumpetfishes	PINGUIPEDIDAE	Sandperches
FISTULARIIDAE	Cornetfishes	BLENNIDAE	Blennies
SYNGNATHIDAE	Pipefishes	GOBIIDAE	Gobies
	Seahorses	ZANCLIDAE	Moorish idol
SCORPAENIDAE	Scorpionfishes	ACANTHURIDAE	Surgeonfishes
SERRANIDAE	Anthias	SIGANIDAE	Rabbitfishes
	Groupers	BOTHIDAE	Lefteye flounders
APOGONIDAE	Cardinalfishes	SOLEIDAE	Sole
CARANGIDAE	Trevally	BALISTIDAE	Triggerfishes
LUTJANIDAE	Snappers		Picassofish
HAEMULIDAE	Sweetlips	MONACANTHIDAE	Filefishes
NEMIPTERIDAE	Spinecheecks	OSTRACIIDAE	Trunkfishes
LETHRINIDAE	Emperors		Cowfishes
MULLIDAE	Goatfishes	TETRAODONTIDAE	Puffers
CHAETODONTIDAE	Butterflyfishes		
POMACANTHIDAE	Angelfishes		

Table 1. A list of the major fish families that may be found on the coral patches. This list may not be complete.

4.6 Maintenance Requirements

Regular maintenance will be required on transplanted patch reefs to minimize the potential impacts from macro algae, *Drupella cornus* and crown of thorns starfish. It is proposed that for the first 2 months, a maximum of 2 weeks between visits be adopted for this purpose, after this time the effort will be reviewed to assess its effectiveness, and the frequency of maintenance visits either reduced or increased. Maintenance will be done by local counterparts and the time spent and number of people involved on this activity should be recorded so that estimates can be calculated on the amount of effort required to achieve a successful outcome.

There is an abundance of the territorial damsel fish (*Stegastes* spp) on the adjacent fringing reefs that can dominate large areas of habitat and successfully restrict other juvenile fish (particularly herbivores) from feeding in their territories.

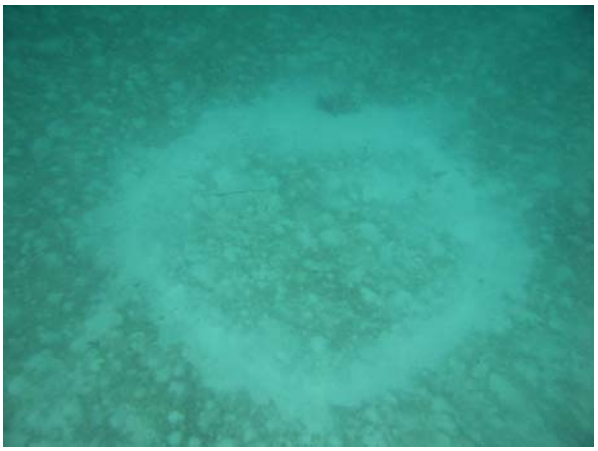
The monitoring program will note any settlement of this species in the new patch reefs and remove this species from the experimental plots using small spear guns. The number and size (total length of each fish) of *Stegastes spp* that are removed will be recorded at each monitoring period.

Donor site

Coral transplant transportation

Transplant cleaning before transplantation

Coral planting



Outlined marked in sand before transplantation

Coral planting

Naturally occuring patch reef that served as a model to create restored patch reefs

Monitoring of transplanted patch reefs →

5 Results

5.1 Baseline Assessment

5.1.1 Coral

The initial and first month post-transplant volume and size of the four patch reefs are shown in Figure 6.

The effect of removing transplant colonies from the donor sites was assessed from before-after photo analyses, and results are presented below (Table 2). The two donor sites were analyzed separately as there was a significant distance between the sites. Donor Site 1 corals were transplanted to patches 1 and 2, and Donor Site 2 corals transplanted to patches 3 and 4.

	LIVE CORAL	MACRO ALGAE	OTHER
SITE 1 PRE	32	62	6
SITE 1 POST	24	72	4
SITE 2 PRE	22	70	8
SITE 2 POST	22	76	2

Table 2. Percent cover of live coral, macro algae and other benthos from the two donor sites before (PRE) and after collection (POST).

The results show that Site 1 had a decrease of 8% live coral cover, and Site 2 did not show any change in live coral cover.

5.1.2 Fish

Initial observations showed very rapid colonization of a low number of fish in the newly created coral patches. Within 30 minutes of the completion of some patches, a small group of Siganidae visited the corals and was eating turf algae from the base of colonies. The turf algae may have been part of former damselfish territories (ex-*Stegastes* territories) at the donor sites. In addition, 2 triggerfish and a few small wrasses (Labridae) were observed to be temporarily present within some patches.

Overall, it was not expected that any fish would establish their territories at this initial patch reef setup stage due to the presence of divers and the sudden appearance of low relief patch reefs. The presence of fish is due to a few

opportunistic species which are known to quickly seek out disturbed areas like the new patches for possible food.

5.2 One Month Monitoring

5.2.1 Coral

The baseline and 1-month monitoring data are shown for the four coral patches in Figures 6 and 7. For the transplanted patch reefs, the mean patch volume of live coral decreased over the first month following transplantation from 82% to 49% of the total patch volumes (i.e., a 30% reduction in live coral has occurred). This initial effect of transplantation has resulted in a reduction in the volume of live coral present in all of the patches, and a subsequent increase in the mean volume of dead coral from 18% to 33% of total patch volumes.

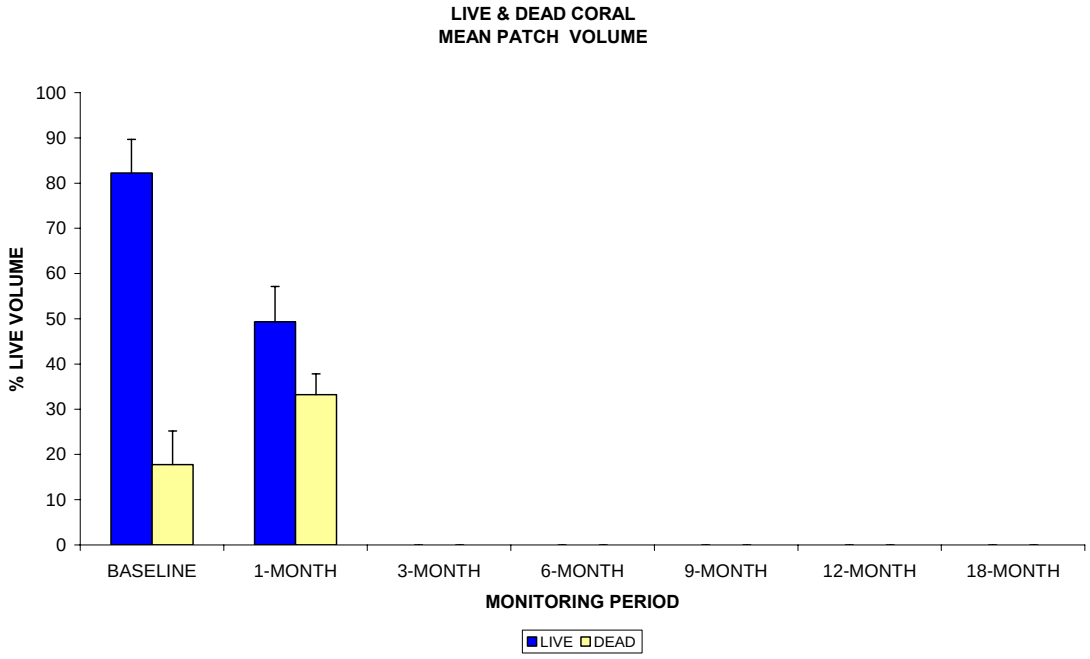


Figure 6. The mean live coral volume from all four coral patches after the first month following transplantation.

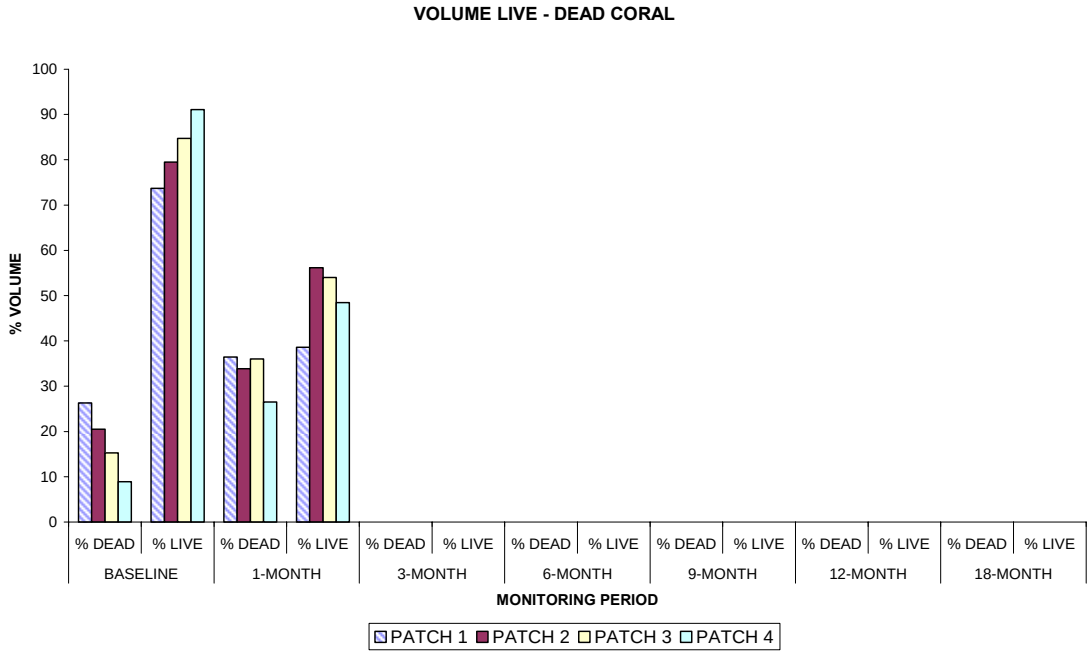


Figure 7. Volume of live and dead coral in each of the patch reefs for the initial baseline and 1-month monitoring period

5.2.2 Fish

A low number of fish (total of 11 fish) were observed at the first monitoring period, 1 month after the establishment of the four patches (Table 3, Figure 8). The fish represented 5 families and included two trigger fish (patches #2 and #4) that may have been the same two that were observed immediately after the establishment of the patches and during the baseline survey. Three juvenile parrot fish were noted among patches #1 and #2, and three small emperor and three goatfish were recorded at patch #3, while 2 fusiliers were recorded at patch #4 along with one of the triggerfish mentioned above.

The sizes of fish observed in the patches were generally small (juvenile size) except for the Mullidae (goat fish), and Lethrinidae (bream), which were medium sized fish (Figure 9).

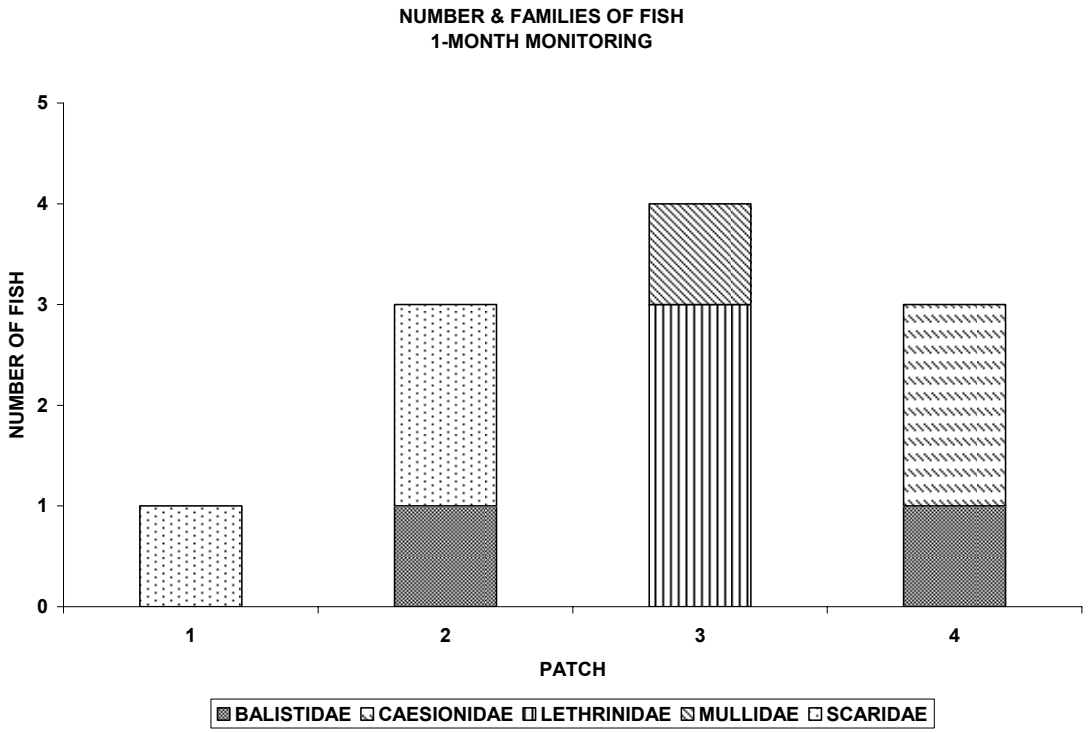


Figure 8. Number and families of fish recorded from the 1-month monitoring survey

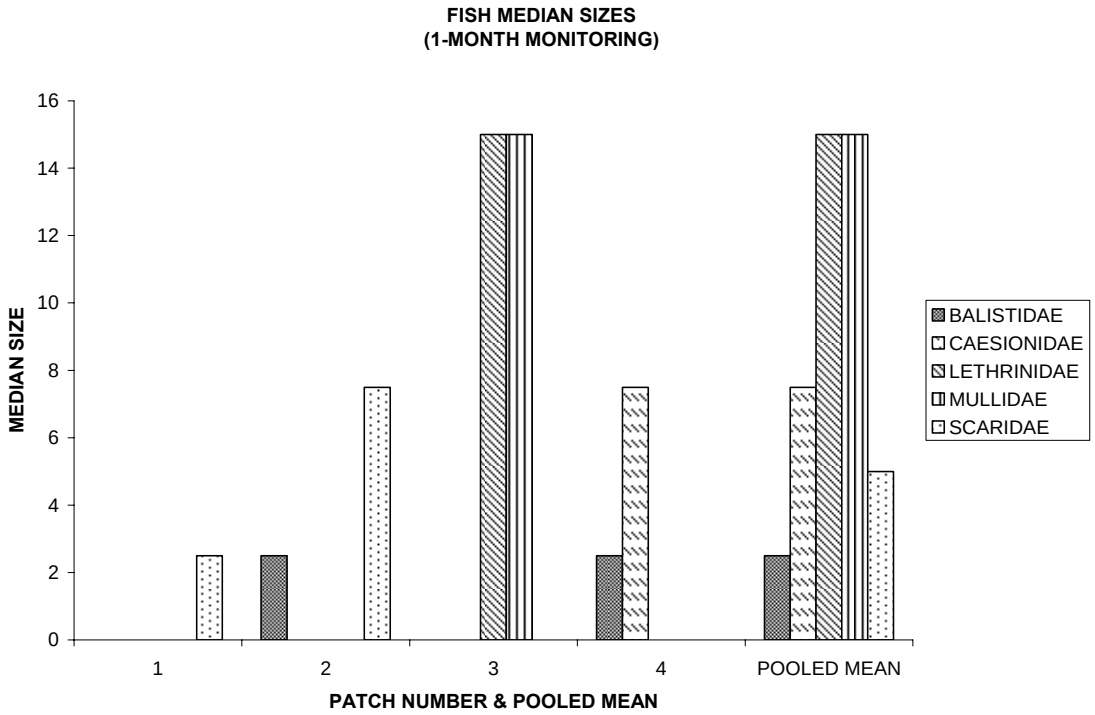


Figure 9. Size classes of fish recorded in the experimental patch reefs

Monitoring Schedule : 1-month Monitoring					
Site: Lofeagai					
FISH FAMILY / GROUP (Main Species)	**PATCH 1**	**PATCH 2**	**PATCH 3**	**PATCH 4**	**TOTAL**
Scarus globiceps (Globehead parrot fish, F. Scaridae)	1-(1)	2-(2)			3
Pseudobalistes flavimarginatus (Yellow margin trigger fish, F. Balistidae)		1-(1)			1
Rhinecanthus aculeatus (Blackbar trigger fish, F. Balistidae)				1-(1)	1
Monotaxis grandoculis (Humpnose big-eye bream, F. Lethrinidae (emperors))			3-(3)		3
Mulloides flavolineatus (Yellow stripe goatfish, F. Mullidae)			1-(3)		1
Caesio caerulaurea (Blue and gold fusilier, F. Caesionidae)				2-(2)	2
TOTAL NUMBER FISH	1	3	4	3	11

Table 3 Number of fish recorded in the four patch reefs after the first month post-transplantation

Key to Data : Number of Fish-(Size Class); Size of fish refers to 1 = <5cm, 2 = 6-10cm, 3 = 11-20cm, 4 = 20-30cm, 5 = >30cm.

6 Effort

The analysis of effort required to establish the four patch reefs shows that more effort was spent in the scoping and design stage compared to the transplantation phase (Table 4). This is an important factor as it is essential that proper due consideration is given to the many parameters that are required to assess the viability of a transplantation project. The high amount of effort spent in the scoping and design phase was also due to the presence of widespread environmental disturbances in Funafuti lagoon, requiring extensive searches for areas that were free of ongoing disturbances. Overall, the time required to design and establish the trials patches amounted to approximately 5.3 person days (if 8 person hrs is equivalent to 1 person day).

The costs involved in establishing the four coral patches were more dependent on wage costs rather than logistical costs. It is also important to note that the presence of a coral specialist is critical to the potential success of such projects as there is a high degree of ecological assessment input into the decision process at the design stage. The low costs incurred during transplantation were also due to the fact that no boat and fuel costs were required as all work was undertaken by swimming from the shore. As well, work was done in partnership with the FSPI local affiliate and Funafuti local government officers. In contrast, there were transportation costs involved in the design phase because of the large distances and range of habitats that were assessed.

ACTIVITY	TIME	PERSONNEL	EFFORT
Effort			
Design	20 hrs	1 consultant	20 person hrs
Transplantation	5.6 hrs	4 persons	22.4 person hrs
Maintenance	0.3 hrs	1 consultant	0.3 person hrs
Overall Effort	**25.9 hrs**	**6 persons**	**42.7 person hrs**
Costs			
TANGO Staff			
Fisheries Staff (Tuvalu)			
FSPI Staff			
Consultant			

Table 4. Summary of effort involved in scoping and establishment of four trial patch reefs

7 *Lofeaga* Community Involvement

The *Lofeaga* community church and school groups were engaged by the TANGO representatives to help raise awareness of the project. The community youth group was taken on a field visit to the restored plots after a presentation was completed at the school. In a PowerPoint presentation the youths were shown the value of restoration efforts on their reefs and the current status of the Lofeaga lagoon fringing reef was explained to them.

A community PLA workshop is planned to be held within the first three month maintenance monitoring period to create awareness with all the community groups, church, youth, school, fishermen and women's groups. This workshop was not able to be conducted earlier due to school holidays and feasting season which coincided with the project establishment phase.

TANGO project staff will be conducting frequent awareness raising activities and field trips for students and science teachers. It is also planned that a group of science students will get actively involved in setting up a separate plot for their science project, including the monitoring of their established plot. To gain knowledge in restoration and monitoring techniques, they will work with fisheries and project staff during the 3-month maintenance trip to build capacity. The community has been aware of the restored area, and the area has been marked by Fisheries staff. The school management is in charge of policing the site from poaching, anchoring and spear fishing.

8 Discussion

The effect of collecting coral from the donor sites was small in one site and negligible at the other site, indicating limited impacts from the transplantation exercise in terms of change in percent live coral cover. However, there may have been some impact on the proportion of 'healthy' or suitable branching coral used for transplantation which was not recorded in the analyses. That is, many colonies in the donor sites were only alive on the outer tips of the colonies or displayed the effects of feeding by *Drupella*, and these were not selected for use. The photo analysis method measured total coral cover only, but not the cover of 'healthy' (suitable for transplanting) verses 'less healthy' (or non selected colonies). In this context, 'healthy' colonies included those which were free of *Drupella* feeding scars and macro algae, and were more or less completely alive except for the lower base areas. This is suggested from a notable gradual increase in the search time for the best colonies at the donor sites, indicating a reduction in the availability of suitable colonies. The overall impact of this unmeasured effect could be in terms of the recovery time of these local coral communities as the most intact and healthy colonies were removed for transplantation.

The reduction in live coral volume and increase in dead coral volume in the early phases after transplantation is to be expected as the transplanted colonies were usually placed on the sand surface or buried in the sand down to the live sections of the colonies at the beginning of the experiment. Therefore, subsequent die back of the live coral sections adjacent to the sand was expected to occur. In addition, some colonies did not recover from the initial transplantation and have died within the first month following transplantation. Once again, some mortality is usually expected due to the change in habitat and also because some colonies were probably moved 2-3 m deeper than where they were collected on the fringing reef slope. The transplanted corals also require time to adapt to the different habitat from their source which may help explain the apparent lack of noticeable growth despite the high summer growth period that would be expected in corals.

Although the numbers of observed fish is low after the first month post establishment, it is encouraging to note that many of the newly settled fish were juveniles, indicating that the patches will act as attractive habitat for fish recruitment. The 1-month monitoring time occurred in summer when many juvenile fish normally settle onto reefs, but the time period following establishment is too short to conclusively demonstrate any effect of the patch reefs attracting juveniles. This is predominantly due to the lack of time for the transplanted corals to adapt and grow sufficiently to produce suitable habitat, especially with respect to protection and cover for the juveniles.

The only concern is the presence of the highly territorial trigger fish that may be able to chase other fish species away from their new territories. Future monitoring will demonstrate whether this is a reality or not.

9 Future Work Schedule

The maintenance and monitoring schedule commenced 1-month after the establishment of the coral patches and completion of the baseline assessment in late November 2006 (Table 5). It is proposed that more regular monitoring and maintenance activities are undertaken in the early stages of the project and that this schedule will be reviewed regularly as the project progresses. Initially it is proposed that 1-month, 6-month, 12-month and 18-month monitoring times will be carried out. In addition, at 3-month, 9-month and 15-month maintenance trip will be carried out by the local team. For the first 2 months, it is proposed that maintenance visits be conducted every two weeks and that the amount of maintenance time required is recorded so that a review of this schedule can be carried out after this period.

	2006			2007													2008					
Activities	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Tuvalu scoping exercise																					
Scoping report																					
Initial Project set up and community consultation																					
1-month monitoring and community workshop																					
3-month maintenance trip																					
6-month monitoring survey																					
9-month maintenance trip																					
12-month monitoring survey																					
15-month maintenance trip																					
18-month final monitoring survey																					

Table 5. Work plan for Restoration Experiment 1
Tuvalu sand based patch reef transplantation trial

10 References

Berdach, JT (2003). Case Study: The Funafuti Conservation Area, Funafuti Atoll, Tuvalu. Drawing Lessons for Future Marine Conservation Planning and Management. Prepared for the Government of Tuvalu. Asian Development Bank, Pacific Region Environmental Strategy (ADB TA No. 6039-REG). Pp.39 plus annexes.

Fisk, DA, Job S, Bowden-Kerby A, Khan Z, Nainoca F (2006). AFD Moturiki Coral Research Project Monitoring Report (1, 3, 6, 9 months). Final Report to FSPI, Suva, Fiji Islands.

Fisk, DA (2006). Coral Transplant Trials, Funafuti Atoll, Tuvalu. Scoping Exercise for the Selection of Suitable Sites. Report to FSPI, Suva, Fiji Islands. Pp. 16.

Government of Tuvalu. (1998). Conservation aArea Act of 1998.

Kaly, Ursula L (1997). Monitoring training & first survey of Funafuti Marine Conservation Area, Tuvalu. Report 1. SPREP/Funafuti Town Council.

Kaly, Ursula L et al (1999). Second marine survey of Funafuti Conservation Area, Tuvalu. Report 2. SPREP/Funafuti Town Council.

Kohler, K.E. and S.M. Gill. (2006). Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Computers and Geosciences, Vol. 32, No. 9, pp. 1259-1269. DOI: 10.1016/j.cageo.2005.11.009

South Pacific Regional Environment Programme (SPREP) (1993). South Pacific Biodiversity Conservation Programme (SPBCP).Project Document. RAS/91/G31/E/1G/99. Apia, Western Samoa.

Appendix 1. Monitoring datasheets for coral and fish.

TUVALU FISH MONITORING

(Number of Fish – Size Class)

Site:	**Date**:	**Schedule**:		**Obs** :
FISH FAMILY / GROUP (Main Species)	**PATCH 1**	**PATCH 2**	**PATCH 3**	**PATCH 4**

Size Classes : **1**=1-5cm (finger tip to first joint) **4**=20-40cm (finger tip to elbow)

2=5-10cm (finger tip to knuckle) **5**=40+cm (elbow+)

3=10-20cm (finger tip to wrist)

TUVALU CORAL MONITORING

Site:	**Date:**	**Schedule:**		**Obs** :
	PATCH 1	**PATCH 2**	**PATCH 3**	**PATCH 4**
MORTALITY (%)				
BLEACHING (None – Slight – Partial - Major)				
DRUPELLA / COTS (# Removed)				
MACROALGAE (None – Low - Medium - High)				
DIMENSIONS (cm)	**PATCH 1**	**PATCH 2**	**PATCH 3**	**PATCH 4**
Max. Diam (LxB) =				
Dead / Total Ht = D1 / T1				
D2 / T2				
D3 / T3				
D4 / T4				
D5 / T5				
D6 / T6				

(**DEAD / TOTAL HEIGHTS**: From sand to upper dead & upper live branch tips; cm)