MAMANUCA ISLANDS
CORAL REEF CONSERVATION PROJECT

Year Three Report- 2005

-Prepared by-

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Acknowledgements

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Executive Summary

- The Fiji Coral Reef Conservation Project (FCRCP) in the Mamanuca Islands has entered it's third year and phase of operation.
- In this year, 93 baseline transects gave been completed involving 534 dives and accruing some 38,000 in-water recordings on the coral reef communities
- From this data collected, the final 6 MPA sites required to form an Integrated Marine Management System in the Southern Mamanucas have been identified, and the following recommendations have been made

Recommendation 1 – Finish remaining transects and Reef Check dives in the Southern Mamanucas to ensure a comprehensive dataset is available.

Recommendation 2 – Move north so that the Northern Mamanucas can be surveyed. It is anticipated that surveys in the Northern Mamanucas will yield additional recommended sites for the establishment of Marine Protected Areas.

Recommendation 3 – Continue to offer assistance and support to the Mamanuca Environment Society with the implementation of the recommended Marine Protected Areas and with community education and awareness.

Recommendation 4 – Having moved the main thrust of survey effort to the Northern Mamanucas, provision needs to be made for a base for the Mamanuca Environment Society for which CCC will provide a staff team presence. MES can then utilise this base as a centre for education, training and monitoring. This is an essential step to ensure the continuity of the work conducted to date and ensure that the management recommendations made to date are delivered in an efficient manner to management decision makers.

Recommendation 5 – Seek sources of funding to support this next phase of CCCs work in the Southern Mamanucas.

Introduction

This is the third annual report that Coral Cay Conservation (CCC) has prepared on its work in the Mamanuca Islands as part of the Fiji Coral Reef Conservation Project (FCRCP). Since the full time project began in March 2002, much progress has been made in assessing the marine resources of the Mamanuca Islands, and subsequent projects have presented themselves with CCC working in 3 different areas of Fiji at one point in late 2004/early 2005. The work in the southern Mamanucas has now entered a third phase[1] in it's existence; the baseline survey work of the reef system in the Southern Mamanucas is now largely complete, with emphasis being placed on community work and capacity building measures with our local counterparts, the Mamanucas Environment Society (MES). Indeed, as CCC move towards the end of their third full year in the Mamanucas, great efforts are now being made to ensure that the recommended Marine Protected Area sites and other management initiatives that can be taken and have been recommended by CCC over the last three years of exhaustive baseline surveying are disseminated effectively to the decision makers.

Readers of our previous reports will notice that this report is abridged. Full details of methodology and analysis techniques are available in copies of our previous two annual reports which are available in hard copy of in soft copy from the website at www.coralcay.org

[1] The 1^{st} stage being the set up of the full time project and local networking, and the 2^{nd} stage consisting of full time surveying of the reef system with the implementation of community projects and other workshops.

2. Project Background

2.1. The coastal zone of Fiji

The shallow coastal zone of Fiji is comprised of three major, interrelated habitat types: marine algae and seagrass; large areas of mangroves; and extensive coral reefs. The marine resources include approximately 1000 coral reefs with representatives of all major reef types (Vuki *et al*., 2000). Although marine biodiversity is lower than the 'coral triangle' of Indonesia, the Philippines, Papua New Guinea and northeastern Australia, Fiji does support approximately 200 species of coral (Veron, 2000). Furthermore it has been estimated that Fiji has approximately 1200 marine fish species (Vuki *et al*., 2000). Since taxonomic research in the country has been limited, further research will extend the known biodiversity of all marine taxa considerably.

Fiji's current population is approximately 775,000 and increasing rapidly (South and Skelton, 2000). Since much of this population is concentrated around the coast, the expanding development of coastal areas and exploitation of the reefs are resulting in a suite of threats to the coral reefs including siltation, eutrophication and pollution (Vuki *et al*., 2000). For example, some of the natural landscape has been converted for agriculture, particularly sugar cane, which impacts the coastal environment via soil erosion leading to elevated sediment loads smothering coral colonies. Further erosion is also caused by the removal of mangroves to re-claim land for urban development. Such expansion of urban areas has also led to pollution of the coastal zone because of inadequate sewage treatment and waste disposal. Industrial point sources have also been shown to contribute to decreasing water quality.
A recent study of nutrient levels along the Coral Coast of Viti Levu (Mosley and Aalbersberg, 2002) found that levels for nitrate and phosphate exceeded thresholds considered harmful to coral reef ecosystems. Furthermore nutrient levels were highest at sites located near hotels, other populated coastal locations and in rivers.

In addition to coastal development, fishing in Fiji, which occurs at both traditional subsistence and commercial scales, has significantly reduced the populations of many species. Although data are scarce, even traditional techniques, such as hand-lines, fish traps and gill nets, in combination with commercial catches have led to over-fishing of many reef areas. For example, a study by Jennings and Polunin (1996) found low abundances of certain highly targeted fish species, such as groupers and emperors. Over-fishing of prized invertebrate species, such as *Tridacna* clams and sea cucumbers, has also been reported close to urban areas and is thought to have increased since the introduction of SCUBA apparatus and escalating demands of foreign markets (Vuki *et al*., 2000). Fiji is the world's second largest exporter of live reef products for the aquarium trade (Wilkinson, 2002) with a well-established industry that has been operating for over 16 years exporting coral reef fishes and curio coral (Lovell, 2001).

The anthropogenic threats to reef health have been compounded by natural and semi-natural threats such as storm damage, outbreaks of the coral eating crown-of-thorns starfish (*Acanthaster planci*) and coral bleaching events. Bleaching events occur during occasional periods when climate conditions raise seawater temperatures and solar irradiance and cause a paling of coral tissue from the loss of symbiotic zooxanthellae (summarised in Brown, 1997 and Westmacott *et al*., 2000). A major coral bleaching event occurred in Fiji in March and April 2000 and had large-scale effects throughout the country, including the Mamanucas region. For example, South and Skelton (2000) reported bleaching of up to 90% of coral colonies with up to 40% mortality (Sulu *et al*.; in Wilkinson, 2002), although there was significant spatial variation in its severity throughout Fijian waters. There is evidence that many of the corals recovered but mortality was certainly significant although it is difficult to quantify because of the limited long-term monitoring data available. A second less severe bleaching event occurred in the Mamanucas in April 2002 but did not significantly alter the % cover of live hard coral (Walker *et al*., 2002). Fiji is also affected by a severe cyclone every 3-4 years (Vuki *et al*., 2000), causing significant coral damage in shallow water. Population explosions of Crown-of-Thorns starfish (CoTs) have also been recorded since 1979 (South and Skelton, 2000).

Conservation in Fiji has been limited because of conflicts between proposed Marine Protected Areas and local communities' ownership of customary fishing rights. Marine reserves have, therefore, until recently been limited to several privately owned sanctuaries where, for example, resorts have reached an agreement with the holders of fishing rights. Expansion of this network of reserves could be achieved by payment of adequate compensation to those who currently own the rights and rely on them for their livelihoods. There is also a growing network of locally owned and managed MPA's under the umbrella of the Fiji Locally Managed Marine Areas Network (FLMMA) which heavily involves the Institute of Applied Science (IAS) at the University of the South Pacific (USP). The approach of FLMMA advocates the use of conservation education to highlight the advantages of voluntarily established marine reserves, such as increased fish catches and tourist revenue to local communities. Within the last year, FLMMA has grown considerably in Fiji and is now a powerful initiative within Fiji, and an example to the rest of the Asia-Pacific region. CCC has recently embarked upon a new project on the island of Kadavu with the FLMMA network.

2.2. The Mamanuca Islands

Figure 1 illustrates the main Islands and points of interest in the Mamanuca Islands. The map image is based on a Landsat 7ETM+ image acquired in 2003 and is projected on a Universal Transverse Mercator projection and a WGS-84 datum. This satellite image forms the basis of all subsequent GIS outputs in this report.

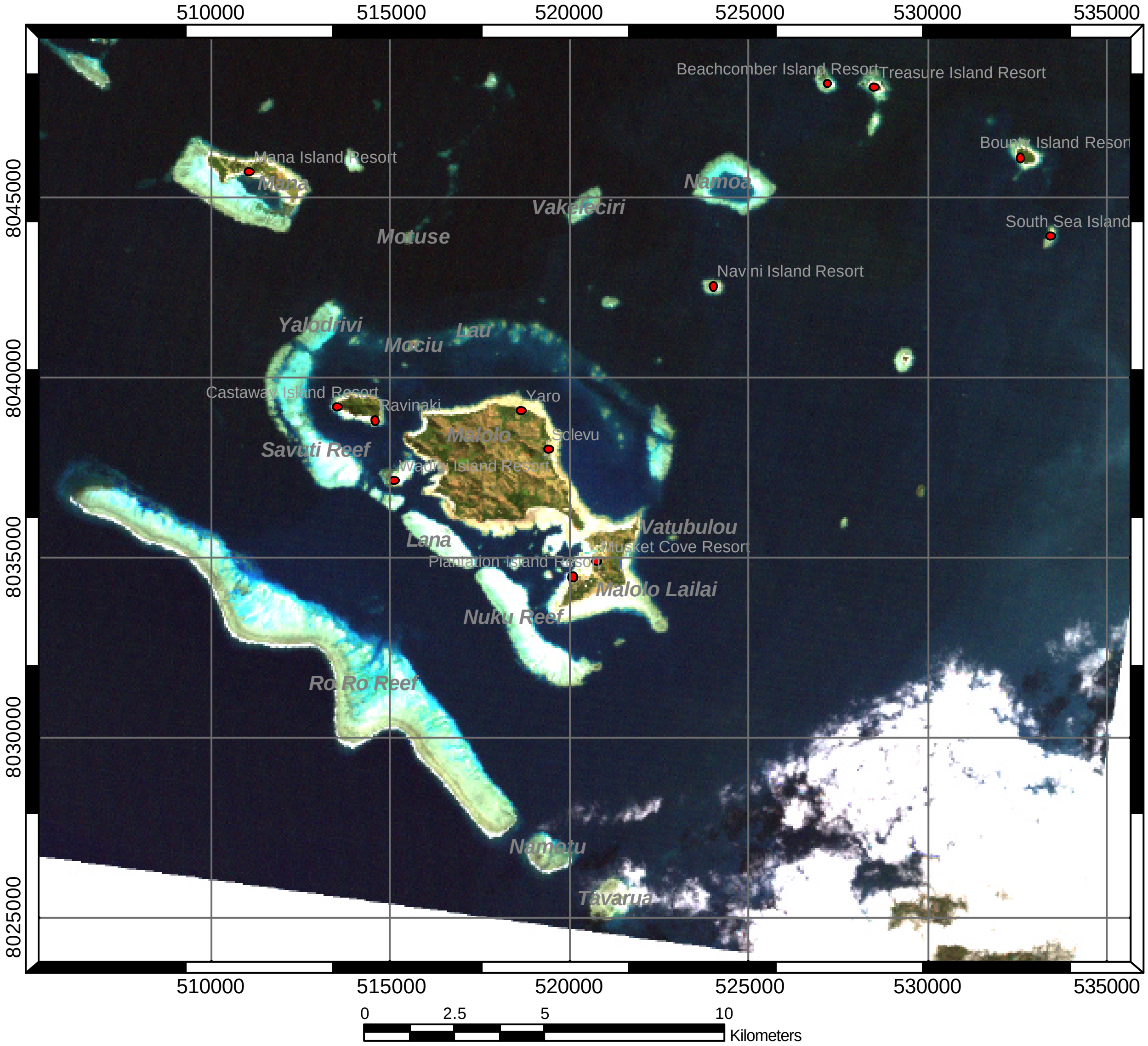

Figure 1 The Mamanuca Islands showing Island names and points of interest.

Along with most other areas of Fiji, the reefs of the Mamanuca Islands suffered from a mass coral bleaching event in March 2000. Local dive operators and resorts reported high mortality of reef building corals, but the extent and scale of the damage has not been quantified. Bleaching was again reported for the Mamanuca Islands in March 2001 and April 2002. The 2001 bleaching event was just prior to Cyclone Sosa passing close to the east coast of Viti Levu and the Mamanucas. The cyclone created substantial waves up to 25 feet high on the Outer Malolo ('Ro Ro') Barrier Reef (Craig Flannery, pers. comm.) and caused physical damage to the reefs at many different sites. Interestingly, there is anecdotal evidence that the water movements caused by Cyclone Sosa may have reduced sea-surface temperatures and allowed some bleached corals to recover. Furthermore, an outbreak of crown-of-thorns starfish was reported in the Mamanucas in 1996 (South and Skelton, 2000). A number of recent corallivorous Crown of Thorns Seastar sightings have been reported at Mothui Island in March 2003 although the scale of this event and any damage caused has not been quantified.

Natural stressors, for example bleaching and cyclones, act synergistically with anthropogenic disturbances such as sedimentation from land development, over-fishing and pollution, which are known to be present in the area. Initiatives are however being taken in the Mamanuca archipelago to prevent much of the anthropogenic degradation of the coral reef resources of the area. The Mamanucas hosts the oldest private sanctuaries in Fiji, established by "Beachcomber Cruises" in the 1970s, which are found around Tai (Beachcomber) and Lovuka (Treasure) Islands. Last year a number of MPAs or *tabu* areas were established on the fringing and patch reefs around Malolo and Qalito (Castaway) Island through the work of Partners in Community Development Fiji (PCDF). The establishment of these *tabu* areas is based on a system modelled on the Fijian customary marine tenure scheme. As stated in last years report, the Mamanuca Environment Society (MES) has been recommended as the implementing body of further MPA/*tabu* areas within the Mamanucas.

2.3. Aims and Objectives

Following the successful pilot survey programme undertaken in 2001 by CCC and local Fijian counterparts a set of ten recommendations were drafted. These involved, but were not necessarily limited to; monitoring, education, setting up a Mamanucas management group, data base acquisition to set up a fully-functional GIS, and to set up multi-user Marine Protected Areas.

Monitoring and data acquisition is ongoing though is nearing completion for the Southern Mamanucas and a fully functional GIS was achieved and is still used as our main analytical tool. The Mamanucas Management Group was born in the form of the Mamanuca Environment Society and has taken on the role of community education and training in conjunction with CCC. Apart from completing the data collection of the last few reefs left to be surveyed, CCC in conjunction with MES now aims to facilitate the implementation by local resource owners a multi-user set of integrated Marine Protected Areas.

3. Methods

As stated in the introduction, details of the methodologies utilised by CCC can be found in the two previous annual reports and at our website, www.coralcay.org. Due to the quantity of community work and local education in third year of CCCs work in the Mamanuca Island, 'Environmental Awareness and Community Work' has been designated it's own complete section of this report. Given below are the methodologies used for the particular analyses presented in this report.

3.1. Benthic data

In order to describe the reef habitats within the project area, benthic and substratum data were analysed using multivariate techniques within PRIMER (Plymouth Routines in Multivariate Ecological Research) software. Data from each Biological Form (which represents a 'snap-shot' of the benthic community from either part or all of a habitat type distinguished by the survey team) are referred to as a Site Record. Multivariate analysis can be used to cluster the Site Records into several groups, which represent distinct benthic classes. Firstly, the similarity between benthic assemblages at each Site Record was measured quantitatively using the Bray-Curtis Similarity coefficient without data transformation (Bray and Curtis, 1957)[2]. This coefficient has been shown to be a particularly robust measure of ecological distance (Faith *et al.*, 1987).

Agglomerative hierarchical cluster analysis with group-average sorting was then used to classify field data. Cluster analysis produces a dendrogram grouping Site Records together based on biological and substratum similarities. Site Records that group together are assumed to constitute a distinct benthic class. Characteristic species or substrata of each class were determined using Similarity Percentage (SIMPER) analysis (Clarke 1993).

To identify characteristic features, SIMPER calculates the average Bray-Curtis similarity between all pairs of intra-group samples (e.g. between all Site Records of the first cluster). Since the Bray-Curtis similarity is the algebraic sum of contributions from each species, the average similarity between Site Records of the first cluster can be expressed in terms of the average contribution from each species. The standard deviation provides a measure of how consistently a given species contributes to the similarity between Site Records. A good characteristic species contributes heavily to intra-habitat similarity and has a small standard deviation. The univariate summary statistics of median abundance of each species, life form and substratum category were also used to aid labelling and description of each benthic class.

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[2] $$\text{Bray - Curtis Similarity, } S_{jk} = \left[1 - \frac{\sum_{i=1}^{p}\left|X_{ij} - X_{ik}\right|}{\sum_{i=1}^{p}\left(X_{ij} + X_{jk}\right)}\right]$$

Where X_{ij} is the abundance of the *i*th species in the *j*th sample and where there are *p* species overall.

Finally, the benthic class of each Site Record was combined with the geomorphological class assigned during the survey to complete the habitat label. The combination of a geomorphological class and benthic class to produce a habitat label follows the format described by Mumby and Harborne (1999).

The habitat classes identified in the FCRCP year two report are also used this year. This has realised the advantage that analysing additional data in this manner ensures consistency between one years data set and the next and is important in the process of developing an exhaustive classification scheme for the entire coral reef area (Mumby and Harborne 1999). The different habitat classes identified are given in Table 1. These defined classes play a key role in the calculation of the Conservation Management Ratings, perhaps the most useful tool CCC use in recommending MPA areas.

3.2. Conservation Management Ratings and Geographic Information System

In order to examine the relative health, diversity and status of the coral reef areas in the Mamanucas, an innovative method of calculation was devised. The theoretical basis behind the conservation management rating system is that areas of coral reef around which Marine Protected Areas should be established to maximise their benefit should be as biodiverse, productive and representative of all habitats (the fifteen most common habitats as described in Table 1). This technique combines many of these variables based upon the classification of coral reef areas that have been surveyed and subsequently classified into a habitat.

Once all survey records had been assigned to one of a discreet number of benthic classes, further analysis based on these subsets of data was performed. The total numbers of species and Shannon-Weiner diversity indices have been calculated on both the benthic community as well as on the fish communities that were recorded by CCC divers at the site of each Survey Record. Finally, values of average hard coral cover from the detailed habitat descriptions for each habitat were also extracted. Average values for each of these biological indicators of reef health were then calculated across the entire data set.

To quantify the spatial distribution of areas of reef, each Survey Record was assigned a rating from one to five. A score of zero on this rating scale equates to the Survey Record belonging to a habitat or benthic class where none of the five univariate reef health indicator variables[3] were above average across all the Survey Records analysed. By contrast, a Survey Record with a score of five belongs to a benthic class where all five variables were above the average value calculated.

Each transect surveyed during the CCC Baseline technique is comprised of a composite of more than one Survey Record, each of which may belong to different benthic classes and therefore have differing degrees of reef health. By splitting each transect into its constituent parts, and weighting the composition of each transect according to the length surveyed, it was possible to construct an overall reef health

[3] The aforementioned total no. of species, Shannon-Weiner indices and average hard coral cover calculations.

statistic for that survey transect ranging from 0-5. To facilitate easy interpretation of these values, the following scale was used; where transects scored an overall rating >4.5 they were classified as of high management potential, from 3.5-4.5 as moderate management potential and finally below 3.5 of low management potential. With each of these transects being spatially locatable data sets, a map to show the relative management potential of each transect surveyed thus far has been constructed.

The resulting map illustrates point data sources but does not allow the overall interpretation of conservation value of areas surrounding these transect points. To allow this, a unique mapping procedure was performed. The first stage in this methodology was to produce a density grid over the survey area that illustrates the density of the both transects and also the relative management value of these transects. It was realised however that areas of high density could be as a result of higher survey effort in a reef area and not as a result of high management potential rating. To overcome this, another density grid of survey effort was created, the units of which, although arbitrary, represent the number of transects per reef unit area. Finally, by performing a calculation on the raster layers in a Geographic Information System to divide the density grid of management value combined with survey effort and the grid of survey effort alone, the output density grid is weighted for survey effort and represents only the density of management value. This output image was contained in a Geographic Information System that allows users to query and delineate areas of high conservation and management value, to calculate the geographic area comprising these sites and to add, for example, buffer zones of a set distance around each of these sites of interest.

The production of this map is the culmination of the work conducted by CCC in three years of work in the Mamanuca Islands. It has huge potential of use for all stakeholders and allows a degree of flexibility in the choice of Marine Protected Area sites. It is upon this map that the Marine Protected Area recommendations contained in this report are identified.

Table 1. Quantitative description of the fifteen benthic classes defined from the data collected in years one and two of the FCRCP. Figures in parenthesis indicate mean observational abundances from the DAFOR (0-5) semi-quantitative scale as used during CCC Baseline surveys

Habitat	Average depth	Substratum	Hard Corals	Octocorals	Invertebrates	Sponges	Algae/ Seagrass
1- Sheltered upper reef slope supporting stress tolerant massive corals	7.2	Sand (2.1), Dead coral with algae (1.5)	LHC (2.1), Acropora branching (2.0), Porites massive (1.6)	Total cover (1.6), Sarcophyton sp. (0.9), Sinularia (0.5)	Black corals (1.6), Feather star (1.2)	Total cover (1.6), Lumpy (1.2)	Cover green algae (1.4), Green calcareous algae (1.0), Halimeda (0.6)
2- Macroalgae dominated shallow back reef area of bedrock and sand	3.3	Sand (2.8), Bedrock (2.2)	LHC (1.6), Acropora branching (1.2), Porites massive (0.8)	Total cover (0.5), Sarcophyton (0.4), Sinularia (0.2)	Linckia laevigata (1.1), Synaptid sea cucumber (0.8)	Total cover (0.8), Lumpy (0.5), Encrusting (0.3)	Sargassum (3.3), Brown filamentous algae (2.2)
3- Lower reef slope community on sand with a hard coral community dominated by foliose corals	19.1	Sand (2.3), Dead coral with algae (0.8)	LHC (3.0), Acropora branching (2.5), Mycedium elephantotus (1.2), Pachyseris speciosa (1.2)	Total cover (1.5), Xenia sp. (1.3)	Feather star (1.5), Black coral (1.3)	Total cover (1.3), Lumpy (1.2)	Green algae (1.9), Green filamentous algae (1.7), Brown filamentous algae (1.5)
4- Lower reef slope with significant bare bedrock, a diffuse coral community and frequent black coral	17.6	Bedrock (2.1), Sand (1.5)	LHC (2.3), Favites (1.5), Mycedium elephantotus (1.2), Favia (1.0),	Total cover (2.3), Sarcophyton (1.5), Dendronepthya (1.3), Gorgonaicea (1.3)	Black coral (3.2), Feather star (1.8)	Total cover (2.7), Lumpy (2.3), Branching (1.7)	Red coralline algae (2.2), Green calcified algae (2.0), Halimeda (1.8)
5- Shallow upper reef slope areas of predominately sand and rubble substrate with low coral and high macroalgae cover	6.7	Sand (3.0), Rubble (1.3)	LHC (1.5), Acropora branching (1.3), bottlebrush Acropora (1.3), Porites massive (1.3),	Total cover (1.5), Sarcophyton (1.0), Sinularia (1.0)	Basket star (1.3), Diadema urchin (1.0),	Total cover (1.5), Lumpy (1.5), Branching)-.2)	Brown filamentous algae (2.5), Green algae (1.8), Blue green algae (1.8)
6- Shallow upper reef slope community with a significant presence of rubble and opportunistic Acroporid corals	5.3	Rubble (1.5), Sand (1.5), Bedrock (1.2),	LHC (2.6), Non-Acropora submassive (1.6), Acropora branching (1.4), Porites rus (1.9), Diploastrea heliopora (1.1)	Total cover (1.1), Sinularia (0.8), Sarcophyton (0.6)	Linckia laevigata (1.7), Feather star (1.7)	Total cover (1.2), Lumpy (1.2)	Green algae (1.4), Green calcareous algae (1.0), Brown filamentous algae (1.0)
7- Shallow upper reef slope with frequent hard coral cover, mainly branching Acropora. Occasional soft corals and sponges also present	9.6	Sand (2.5), Dead coral with algae (1.6), Rubble (1.2)	Total cover (2.6), Acropora branching (2.0), Non-Acropora encrusting (1.5), Massive Porites (1.2), Favites (1.1),	Total cover (1.8), Sinularia (1.0), Xenia (0.9)	Feather star (1.3), Black coral (0.7), Hydroid (0.7)	Total cover (1.7), Lumpy (1.5), Encrusting (0.8)	Green algae (1.7), Green calcareous algae (1.5), Halimeda (1.2), Tydemania (1.2)
8 Lower reef slope dominated by sand and rubble with occasional hard coral and sponges	17.1	Sand (2.5), Rubble (1.8), Dead coral with algae (1.5)	Total cover (1.7), Acropora branching (1.3), Acropora encrusting (0.9), Favites (0.6),	Total cover (1.3), Sinularia (0.6), Dendronepthya (0.5)	Black coral (0.7), Hydroid (0.4)	Total cover (1.7), Lumpy (1.6), Encrusting (0.7)	Blue green algae (1.3), Red/ brown branching algae (0.9), Red coralline algae (0.6)

Table 1 (cont.). Quantitative description of the fifteen benthic classes defined from the data collected in years one and two of the FCRCP. Figures in parenthesis indicate mean observational abundances from the DAFOR (0-5) semi-quantitative scale as used during CCC Baseline surveys

Habitat	Average depth	Substratum	Hard Corals	Octocorals	Invertebrates	Sponges	Algae/ Seagrass
9 Sand dominated lower reef slope with sparse coral cover but frequent calcified green algae	14.6	Sand (3.5), Rubble (0.9)	Total cover (1.6), Non-Acropora Encrusting (1.0), Favites (0.7), Seriatopora hystrix (0.3)	Total cover (1.3), Sinularia (0.6), Xenia (0.5)	Feather star (0.8), Black coral (0.6)	Total cover (1.6), Lumpy (1.3), Encrusting (0.7)	Green calcified algae (2.1), Green algae (1.5), Halimeda (1.6), Brown filamentous algae (1.3)
10 Lower reef slope with frequent coral cover dominated by encrusting and massive corals and soft corals	9.8	Sand (1.7), Dead coral with algae (1.2)	Total cover (2.3), Acropora branching (2.0), Non-Acropora encrusting (1.7), Favites (1.0), Diploastrea heliopora (0.9)	Total cover (1.6), Sinularia (1.3), Xenia (0.8)	Hydroid (1.3), Synaptid sea cucumber (0.6), Bryozoan (0.6)	Total cover (1.8), Lumpy (1.8)	Red coralline algae (1.6), Green algae (0.9), Green filamentous algae (0.9)
11 Lower reef slope of sand and mud with sparse hard coral cover dominated by branching Acropora	11.2	Sand (3.3), Mud (2.2)	Total cover (1.5), Acropora branching (1.2), Non-Acropora encrusting (0.8), Favites (1.0), Brain- small (0.5)	Total cover (0.5), Dendronepthya (0.3), Sinularia (0.2), Xenia (0.2)	Tunicates (0.5), Hydroid (0.5), Anemone (0.3)	Total cover (0.3), Lumpy (0.3)	Green algae (0.8), Seagrass (0.5), Red brown branching algae (0.5), Coralline algae (0.5)
12 Mid reef slope with sand and rubble. Sparse hard coral cover and mixed green algal assemblage	8.2	Sand (2.8), Rubble (1.9), Dead coral with algae (0.8)	Total cover (1.6), Non-Acropora encrusting (0.5), Acropora digitate (0.3), Acropora branching (0.3)	Total cover (0.7), Sinularia (0.3), Xenia (0.3)	Cone shell (0.2), Linckia laevigata (0.2), Feather star (0.2)	Total cover (0.5), Tube (0.2), Encrusting (0.2)	Green algae (2.3), Caulerpa (1.3), Brown filamentous (1.0), Green calcified algae (1.4)
13 Lower reef slope dominated by rubble and mud with sparse coral cover and red coralline algae	23.2	Rubble (2.3), Mud (1.7), Dead coral with algae (1.3)	Total cover (2.0), Acropora branching (1.3), Acropora digitate (1.3)	Total cover (1.3), Sinularia (1.3)	Nudibranch (0.7), Short spined urchin (0.7)	Total cover (0.7), Encrusting (0.7)	Red coralline algae (1.7), Green algae (1.7), Green calcified algae (1.7)
14 Largely bare lower reef slope substrates of sand and mud	16.2	Sand (3.1), Mud (1.8)	Total cover (0.6), Diploastrea heliopora (0.5), Porites massive (0.3)	Total cover (0.4), Sinularia (0.3)	Feather star (0.1)	Total cover (0.4), Lumpy (0.2), Barrel (0.1)	Blue green algae (0.7), Green algae (0.6), Green filamentous (0.4)
15 Mid reef slope dominated by sand with mixed disparate hard coral cover and filamentous algae	8.9	Sand (3.5), Dead coral with algae (0.8)	Total cover (1.4), Non-Acropora branching (0.6), Non-Acropora massive (0.6), Seriatopora hystrix (0.6), Pocillopora small (0.5), Favites (0.5)	Total cover (1.0), Sinularia (0.5), Sarcophyton (0.5)	Feather star (0.5), Synaptid sea cucumber (0.4)	Sponge (0.9), Lumpy (0.7)	Blue green algae (1.8), Green algae (1.4)

4. Environmental Awareness and Community Work

Remaining an important facet of CCCs work in the Mamanuca Islands, environmental awareness and local capacity building has been highlighted as an important component of the work done in year three of the FCRCP. This work has included liaising directly with the villages of Solevu and Yaro in order to actually implement a network of MPAs. It is also important to note here that all environmental awareness and community work, bar the CCC scholarship programme, is now carried out under the umbrella of the Mamanucas Environment Society, in accordance with Recommendation 1 for CCC, and Recommendations 1 and 2 for the Implementation of MPAs as stated in the second annual review. Presented here is a summary of the community work carried out by CCC over the last year, beginning with a small note about the Mamanucas Environment Society.

4.1. Mamanuca Environment Society

Coral Cay Conservation has continued to be a very prominent member of the Mamanucas Environment Society (MES) throughout 2005, working in close partnership with the Project Manager, Alifereti Qauqau and his assistant, Terri Tuxson. Mr Qauqau's ability to communicate with the local villages and their Ratus has meant that in conjunction with CCC, we have been able to step closer to the implementation of CCC's recommended MPA sites. Mr Qauqau is an asset in teaching the School Environment Programmes; the fact that he is Fijian has meant that with certain difficult concepts, he is able to explain to the children in Fijian, what they otherwise were finding difficult to grasp in English. From working with MES all over the Mamanucas, it has been obvious that both villages and resorts are utilising Mr Qauqau's and Ms Tuxsons knowledge and skills to their full extent, and as a result, the local environment is benefiting greatly.

4.2. Malolo District School Environment Programme

Following the success of the previous school programmes, a revised and more comprehensive Environment Programme was completed with Class 7 of the Malolo District School over 13 weeks between the months of February and April 2005. The programme provides a broad basis in general environmental biology and geography and culminates in 4 sessions specifically devoted to conservation of their immediate (marine) environment. Perhaps one of the most useful sessions in this programme is where the children were encouraged to dramatise different terrestrial and marine conservation issues; demonstrating best practises. Ideas and 'props' were given to the children by CCC volunteers, and Figures 2 and 3 show them acting out their dramatisations. This practical and varied approach to ensuring understanding of important lessons is the one of the key features of the programme. The programme ends with the children taking an exam drawing on knowledge gained over the entire 13-week programme. All the children passed the exam, with some children scoring higher than 90%. Results like these make it clear that the teaching theory, supported by informative and fun practical sessions is a very effective educational methodology. As with last year, the programme shall also be conducted with the Namamanuca Primary School on Yanuya Island. This is due to begin in early September.

Figure 2 CCC volunteers assisting with dramatisations at Malolo District School

Figure 3 CCC volunteers provided props and ideas for the children to make the exercises more fun.

4.3. Environmental Field Day with International School, Suva

Students in their last two years of study at the International School, Suva undertaking the Environmental Science subject went on a three day long field course along the Coral Coast near Cuvu on the 22nd April 2004. The CCC Project Scientist was asked by their teacher, Mrs Litiana Temo to join them for the first day, give a presentation to them on the work that CCC does, and to assist in their understanding of basic survey methodology (such as intercept transects and belt transects). The students were specifically testing out survey strategies within one of the local MPA sites just outside of Sigatoka, and the CCC Project Scientist was able to teach the students some basic species identification too.

4.4. Coral Cay Conservation Student Scholarship Programme

The CCC Student Scholarship Programme is a month long course which allows suitable candidates (usually selected by our project partners such as the Ministry of Tourism and the University of the South Pacific) the chance to become trained in CCC baseline survey methodology. If they are unable to SCUBA dive, then there is the opportunity for them to be trained to PADI Advanced Open Water standard. The programme is aimed at placing back into the local communities from all over Fiji, people who have the ability to survey and recognise the many indicator species that CCC use to make their recommendations for Marine Protected Areas.

One example of CCCs scholarship programme was in May 2005, when a candidate put forward from Leje Rotuma, Mr Irava Tuatako, embarked upon the CCC Scholarship Programme. Already a PADI Divemaster, Irava went straight into two weeks of intensive science training along with all the other CCC volunteers. After successfully completing the science training, Irava then assisted with two weeks of surveying the coral reefs in the Mamanucas. Irava has now been able to go back to Leje Rotuma and share his newly gained knowledge and skills. We are very grateful to Irava for the work he did with us.

4.5. Matamanoa Island Resort Barge Impact Assessment

Matamanoa Island Resort is a member of MES and is both environmentally aware and proactive. They are part of the Dive Operators Reef Check Network and annually review their Reef Check skills in a ‘refresher’ workshop held by MES. Aware that damage had been done to their fringing reef directly opposite the resort where the fresh water delivery barge had run aground, Matamanoa asked if CCC and MES could carry out an impact assessment, as they were concerned over the potential loss of coral and fish life, which is not only of intrinsic value to them but also of economic value in that their customers wish to experience beautiful untouched reefs when snorkelling. Thankfully the damage was limited to a relatively small 20m ‘impact zone’ and the report is available from either MES or CCC. This is a perfect example of how CCC/MES help the Mamanucan community and demonstrates that community members are beginning to become proactive and aware of the environmental services available to them.

4.6. Dive into Earth Week 2005

In May of this year, MES, in partnership with CCC embarked upon 4 days of beach clean up activities with villagers from the 4 villages of the Mamanuca Islands. Also present were the dive operators of Castaway Resort, Aquatrek Mana, Dive Tropex and Subsurface Beachcomber. Table 2 below depicts the timetable of Dive into Earth Week and those present on each day.

Table 2 Parties present at each day of Dive into Earth Week, 2005

Day/Date	Village	Parties Present
Tue 31st	Solevu	MES, CCC volunteers and staff, Subsurface Beachcomber, Aquatrek Mana
Wed 1st	Yaro	MES, CCC volunteers and staff, Castaway Diving
Thu 2nd	Tavua	MES, CCC staff, Aquatrek Mana, Dive Tropex
Fri 3rd	Yanuya	MES, CCC staff, Castaway Diving, Dive Tropex, Aquatrek Mana

The first day of clean up activity was extremely successful with CCC, MES and many villagers from all sectors of the community becoming involved, picking up litter and discarded goods off the beach and around the village (Figure 4). Subsurface Beachcomber and Aquatrek Mana both came to snorkel the reef flat outside the village to pick up any rubbish that may have entered the reef lagoon. Fortunately, very little rubbish was found in the water, although more than 100 bags of refuse was collected from the beach. The village, especially Ratu Seva, were very grateful for the work that all the volunteers had done that day. The interaction of MES and CCC with the village that day also strengthened our ties to Ratu Seva and talks of implementing our recommended MPAs.

The final day of the clean ups saw the villagers and school children of Yanuya helping in picking up litter and refuse from the beach (Figure 5). Approximately 30 bags of rubbish were collected at Yanuya with a couple of bags of glass bottles and metal collected from under the water in the reef lagoon by the Divemasters of Aquatrek Mana (see Figure 6).

All rubbish collected was ferried to industrial bins on mainland Viti Levu each day. Whilst the majority of rubbish collected was of a plastic origin, there was a huge amount of metal waste too, mostly in the form of corrugated iron sheets. This suggests that there is no formal waste management plan in place within the villages as of yet. The aforementioned school programme addresses this issue with the children of the village.

Figure 4 Dive into Earth Day at Solevu Village, Malolo Island

Figure 5 Dive into Earth Day, Yanuya Village, Yanuya Island

Figure 6 Aquatrek Mana Dive Masters clean rubbish off the lagoon floor

5. Results

In this report, detailed analysis has been restricted to that of the Conservation Management Rating Geographical Information System map. This map draws upon all data collected, including the benthic data, the habitat types subsequently identified and the coral reef fish communities found associated with these habitats. One will remember that it is desirable to set up protected areas that are representative of all habitats; this maximises the biodiversity and productivity found within the recommended MPA network.

5.1. Survey Progress

Of the thirty originally proposed survey sites within the 9 identified survey sectors (Figure 7), all but two have now been completely surveyed. Figure 8 shows the location of the survey work of year three. In total, 93 baseline transects gave been completed in year three involving 534 dives and accruing some 38,000 in-water recordings on the coral reef communities.

Some sites have received extra survey effort (especially the recommended MPAs of Years 1 and 2) and a few relatively isolated patch reefs north of Mana are currently being surveyed.

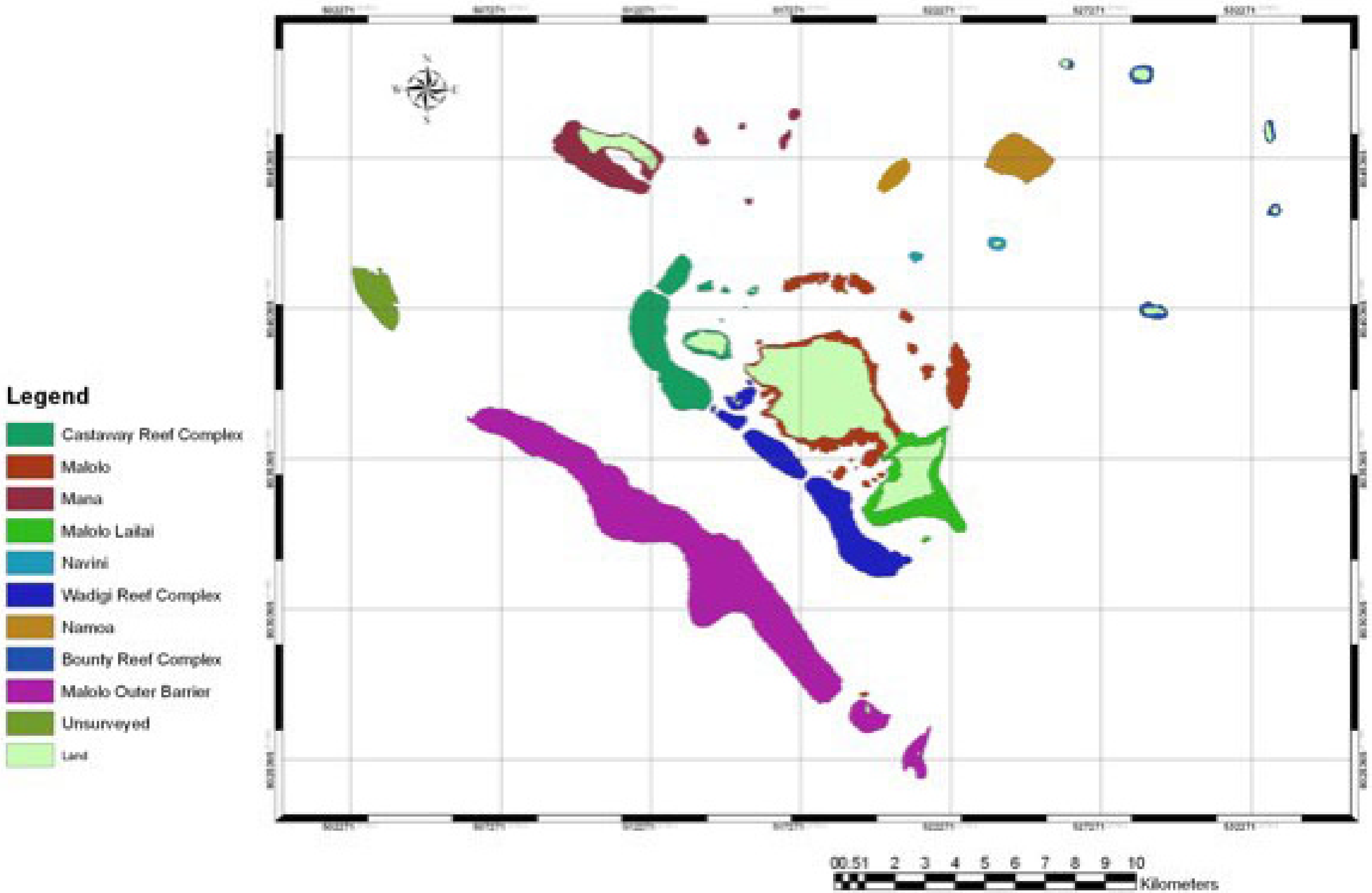


Figure 7 Map of the Mamanucas, showing completed survey sectors

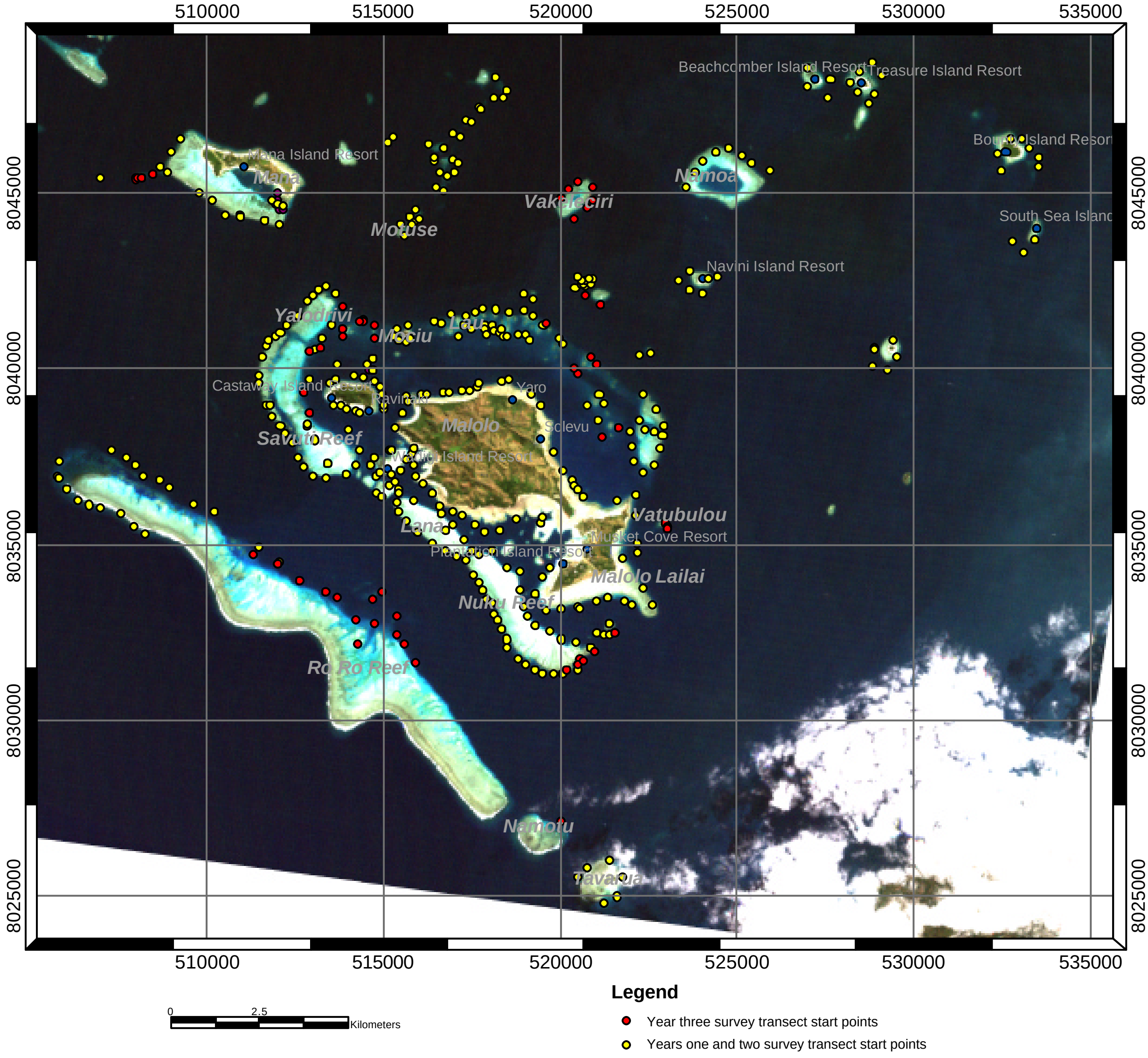


Figure 8 Location of survey transects carried out in years one and two (yellow dots) and year three (red dots).

5.2. Conservation Management Rating and Geographic Information System

Year three has yielded a number of new areas with high Conservation Management Value (CMV) that can be identified from the map overleaf (Figure 9). It is important to note that these are newly identified areas simply because it is the first time these areas have been surveyed, not that originally unhealthy areas of reef have suddenly become more healthy or diverse. A large portion of the Outer Barrier (number 12 in table 3) is of a high CMV and this section spans a large geographic area. Indeed, the Outer Barrier is the largest section of reef within the Southern Mamanucas System and marks the beginning of the Fiji Barrier Reef System, a huge system that extends from mainland Viti Levu, past the Mamanucas and Yasawas and onto Vanua Levu. The North Western tip of Malolo Lailiai (13) and the fringing reef of Vatubulou Island (Sail Rock) also have a high CMV (14). Within the same locale, although surrounded by areas of relatively poor CMV, the far eastern tip of the Inner Barrier (15) is also seen to possess a high CMV. Perhaps unsurprisingly, given that other sections of the Malolo Patch have been already identified as of a high CMV, Lau West (16), a newly surveyed section of the Malolo Patch reef has been identified as of considerable biological value to the reef system. Finally, the relatively isolated patch reef of Vakalaveri has been acknowledged as an area of high CMV, although the northern section of this reef descends to being of only medium CMV.

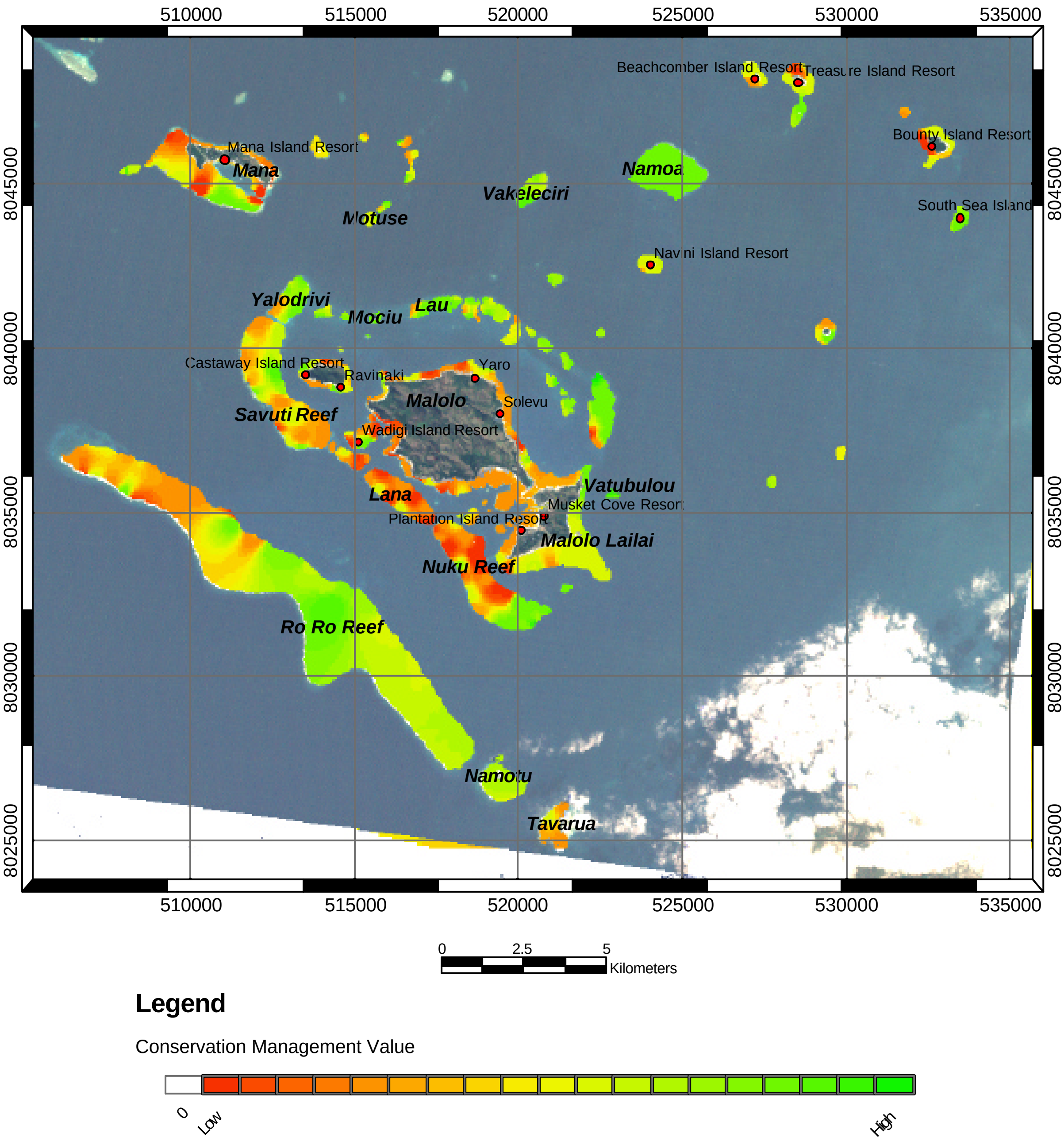


Figure 9 Geographical Information System depicting the Conservation Management Rating of the reefs of the Southern Mamanuca Islands

6. Discussion

6.1. Survey Progress

Recommendation 1 of the 2004 Mamanuca Islands Annual Report stated that baseline and Reef Check data collection in the Mamanucas should continue. It is clear from the results that this recommendation has been achieved and in fact is now nearing completion. In accordance with Recommendation 2, the area of survey has been expanded, and plans are currently being made to extend the survey effort into the Northern Mamanucas with a CCC base on Tokoriki Island.

6.2. Conservation Management Rating and Geographic Information System

The Conservation Management Rating methodology used in this report is the same as the one utilised in the last report, and is the result of a culmination of both multivariate and univariate statistics. Similarly to last year, the areas identified as being of the highest CMV, are then recommended as Marine Protected Areas. The GIS presented in Figure 9 is the perfect medium for presenting to all interested stakeholders the location and spatial distribution of the recommended MPA system. Many other non-biological variables can be included in the GIS too, which allows socio-economic factors to be taken into consideration as well.

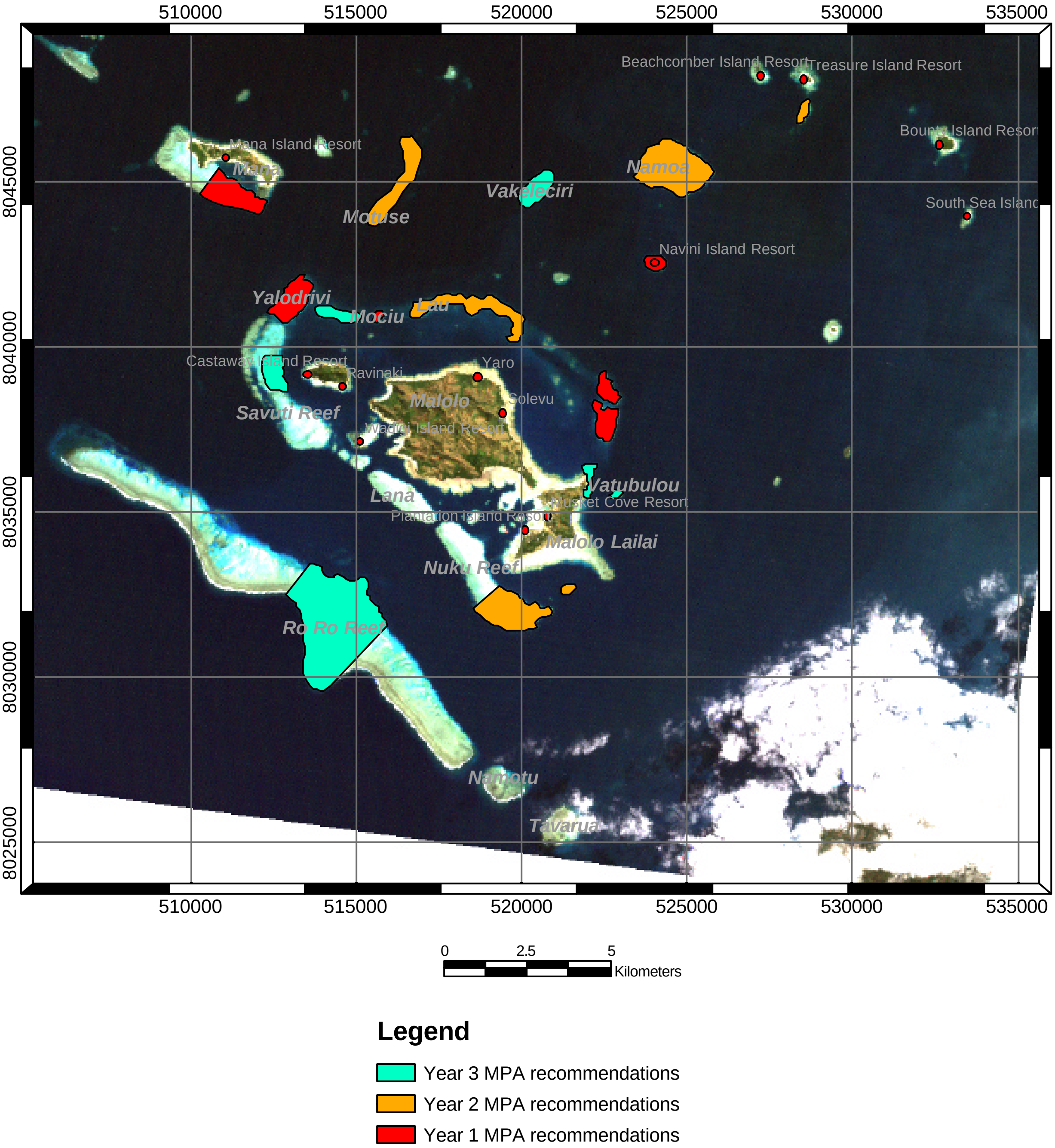
6.3. Management Findings and Recommendations

The original benchmark set for MPA implementation following the pilot project of CCC was for 20% of the shallow reef areas of the Mamanuca Islands to be declared a no-take fishing zone. This equates to 18km^2 in the Mamanucas. At the end of last year, the 11 recommended MPAs consisted of a total conserved area of 11.38km^2 (or 63.2% of the 20% benchmark). This report recommends a further 6 MPAs (Figure 10) and the total spatial statistics of MPA recommendations for all three years of the FCRCP are given in Table 3. The recommendations from all three years cover an area of 20.29km^2, accounting for 22.5% of the total reef area for the Mamanucas. This means that an MPA system has now been recommended that not only fulfils, but also supersedes the 20% protection benchmark.

Table 3 Name, Area and Geographic Location of all recommended MPA sites from each year of the FCRCP.

MPA Recommendation	Area (Km^2)	Perimeter (Km)	Boundaries			
			Lower Left	Lower Right	Upper Left	Upper Right
Year 1						
1- Malolo Patch	1.25	5.82	8036980, 522090	8036980, 522917	8039243, 522090	8039243, 522917
2- Mociu	0.08	1.12	8040796, 515469	8040796, 515838	8041106, 515469	8041106, 515838
3- Yalodrivi	0.89	3.87	8040785, 512431	8040785, 513650	8040785, 512431	8040785, 513650
4- Mana	1.31	5.43	8,044,149, 510,157	8,044,149, 512,242	8,045,593, 510,157	8,045,593, 512,242
5- Navini	0.22	1.85	8042271, 523652	8042271, 524271	8042733, 523652	8042733, 524271
Year 1 recommendations total	3.75	18.09				
Year 2						
6- Sunflower	0.12	1.30	8032520, 521172	8032520, 521628	8032866, 521172	8032866, 521628
7- Nuku	1.79	6.02	8031475, 518542	8031475, 520937	8032777, 518542	8032777, 520937
8- Lau East	1.51	9.79	8040141, 516622	8040141, 520066	8041597, 516622	8041597, 520066
9- Motuse	1.38	7.06	8043642, 515329	8043642, 516966	8046303, 515329	8046303, 516966
10- Namoa	2.66	6.46	8044503, 5233376	8044503, 525780	8046279, 5233376	8046279, 525780
11- Nukuwasiga	0.17	1.78	8046752, 528288	8046752, 528675	8047481, 528288	8047481, 528675
Year 2 recommendations total	7.63	32.41				
Year 3						
12- Outer barrier	6.75	11.11	8029626, 512893	8029626, 515951	8033476, 512893	8033476, 515951
13- Malolo Lailai	0.26	2.92	8035426, 521818	8035426, 522286	8036498, 521818	8036498, 522286
14- Sail rock	0.08	1.07	8035413, 522656	8035413, 523063	8035712, 522656	8035712, 523063
15- Inner barrier	0.66	3.40	8038667, 512190	8038667, 512943	8039770, 512190	8039770, 512943
16- Lau West	0.45	3.24	8040758, 513755	8040758, 515151	8041282, 513755	8041282, 515151
17- Vakalaveri	0.71	3.44	8044231, 519868	8044231, 520960	8045342, 519868	8045342, 520960
Year 3 recommendations total	8.91	25.18				
Years 1,2&3 recommendations total	20.29	75.68				

Figure 10 Location of all recommended MPA sites



7. Recommendations

The Year 2 report consisted of two sets of recommendations: one set specifically dealt with future work of CCC in the Mamanuca Islands, and the second set referred solely towards the implementation of Marine Protected Areas. As has been made apparent in this report, the CCC specific recommendations have nearly all been achieved, though there is still work remaining in relation to the MPA implementation. The recommendations given below therefore reflect this fact.

Recommendation 1 – Finish remaining transects and Reef Check dives in the Southern Mamanucas to ensure a comprehensive dataset is available.

Recommendation 2 – Move north so that the Northern Mamanucas can be surveyed. It is anticipated that surveys in the Northern Mamanucas will yield additional recommended sites for the establishment of Marine Protected Areas.

Recommendation 3 – Continue to offer assistance and support to the Mamanuca Environment Society with the implementation of the recommended Marine Protected Areas and with community education and awareness.

Recommendation 4 – Having moved the main thrust of survey effort to the Northern Mamanucas, provision needs to be made for a base for the Mamanuca Environment Society for which CCC will provide a staff team presence. MES can then utilise this base as a centre for education, training and monitoring. This is an essential step to ensure the continuity of the work conducted to date and ensure that the management recommendations made to date are delivered in an efficient manner to management decision makers.

Recommendation 5 – Seek sources of funding to support this next phase of CCCs work in the Southern Mamanucas

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