BASELINE SURVEY: ASSESSING ABUNDANCE OF COMMERCIALLY IMPORTANT INVERTEBRATES OF THE MARAPA AND SIMERUKA MARINE PROTECTED AREAS, MARAU SOUND, GUADALCANAL.

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A REPORT COMPILED FOR FSPI

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Peace long olgeta man antap long land and olgeta risos insaet long solwata!

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SUMMARY

Following a request made by the people of Marapa and Simeruka communities of Marau Sound through the Coral Gardens Project, a team comprising personnel from the Department of Fisheries and ECANSI visited the two communities from 3rd to 9th April, 2004. During this trip, a number of activities were undertaken by the team. This included a baseline survey on commercially important marine invertebrates of the Marapa and Simeruka community initiated and managed Marine Protected Areas, training of selected community representatives on species identification (invertebrate species) and survey methods as well as education and awareness activities in the stakeholder communities.

The baseline survey of marine invertebrates involved the use of transects. Invertebrates in two types of habitat; shallow and deep, were surveyed. The shallow habitat constituted the reef terrace of depth 1 – 4 m. The deep habitat comprised the slope below the terrace of depth 14 – 30m. Surveys in the shallow habitat were done using 2m X 50m transects whereas in the deep habitat, surveys were done using 5m X 50m transects. Six transects were laid in the shallow and 5 in the deep. Data were collected on the numbers and sizes of important marine invertebrates.

Results obtained from this baseline study showed that the abundance of important marine invertebrates in study area of Marau is extremely low compared to what is reported in other places. Sea cucumber abundance is very low both in the shallow and deep habitats. In the shallow habitat, giant clams and Trochus (Trochus niloticus) stock abundance are also very low. Blacklip pearl oyster (Pinctada margaritifera) was found in low numbers as well. A number of conclusions were made to highlight these results.

This baseline study is designed to compare "before" and "after" declaration data for the Marapa and Simeruka Marine Protected Areas. In doing so, the effectiveness (or success) of the two MPAs can be detected.

1.0 INTRODUCTION

Marine protected areas (MPAs) are established for many purposes (Alder, 1996) and are seen as an important means of managing marine resources (Bohnsack, 1990 and 1993; Dugan and Davis, 1993; Roberts and Polunin, 1993; Sladek Nowlis and Roberts, 1997 & 1999; Parish, 1999; Babcock et al., 1999; Kelly et al., 2000). Briefly, some of the potential benefits of MPAs as pointed out by these authors include:

1) Sources of propagules to replenish areas depleted by over-exploitation.
2) Conservation of habitats, species diversity and genetic diversity (so-called heritage benefits – Parish 1999).
3) Maintenance of large populations of organisms and large individuals within such populations, leading to increased egg production.
4) Replenishment of adjacent, non-protected areas by movement of larger individuals (e.g. either by random movement or density dependent processes).
5) Change in habitat structure due to changes in habitat-forming organisms (e.g. increases in benthic primary productivity as an indirect result of changes in fishing activity – Babcock et al., 1999).

The Arnavon Marine Conservation Area (AMCA) was the first officially established marine protected area in Solomon Islands. It was established in 1995. The effectiveness of an MPA in Solomon Islands was demonstrated at the AMCA by Lincoln-Smith et al., 2000 and Lincoln-Smith and Bell (1996) discussed in detail the AMCA study rationale and the literature and other background materials.

Through the Coral Gardens Initiative: ***Poverty Alleviation Through Capacity Building in community-based Fisheries Management and Coral Reef Restoration Project***, the Marapa and Simeruka communities of Marau on Guadalcanal, approached and requested the Foundation of the Peoples of the South Pacific International (FSPI) and the Environmental Concerns Action Network of Solomon Islands (ECANSI) to assist them with the establishment and monitoring of their community initiated and managed MPAs. The Department of Fisheries and Marine Resources (DFMR), a partner in the Coral

Gardens Initiative project sees this as an opportunity to collaborate (and strengthen partnership) with the communities, FSPI and ECANSI in the process, especially with regard to training and the establishment of a simple and appropriate monitoring regime for these new MPAs.

Following close consultation with the stakeholder communities, a simple monitoring regime (based on the AMCA study rationale) was identified for the two Marau community MPAs. Basically, the monitoring regime require collecting data on abundance and average body size of commercially important invertebrates such as trochus (*Trochus niloticus*), sea cucumbers (Holothuridae) and giant clams (Tridacnidae) within shallow reef terrace and deep slope habitats at several sites within the MPAs and appropriate reference areas prior to and after the establishment of the MPAs. Such a regime will allow for detecting the effectiveness of the MPAs through the comparison of data collected prior to and after the MPA establishment.

With the funding assistance from FSPI under the Coral Gardens Initiative, a team of Fisheries and ECANSI personnel visited the Marau stakeholder communities from 3rd to 9th April to initiate baseline data collection on important invertebrates (commercial & subsistence) and at the same time provide relevant training to selected community representatives in appropriate survey methods. There was assurance from stakeholder community Leaders that on completion of this baseline survey, the MPAs would be officially declared. This baseline survey therefore, will provide a set of data for comparison with future surveys.

Specific activities undertaken during this baseline survey include,

a) field data collection
b) species identification training
c) survey methodology training
d) collection of subsistence and commercial use of fisheries resources in the project communities (basis for selection of monitoring regime) and

e) education and awareness raising

This report presents the result of the baseline survey carried out by the team for the two community MPAs.

2.0 METHOD

2.1 Study Sites

The areas selected for this baseline study consisted of both the MPAs and suitable reference areas and is given in Figure 1. The communities themselves were responsible for the selection and the demarcation of their respective MPA boundaries. Site descriptions and GPS positions (latitude and longitude) are given in Table 1 (a) & (b).

2.2 Survey Procedures

The survey procedures used in this baseline study is adopted from the AMCA study and is described in detail by Lincoln-Smith and Bell (1996). The procedures and the sampling methods are selected for the following reasons:

(i) Stakeholder communities consider marine invertebrates as very important part of their livelihood and requested that they be assisted in the monitoring of these marine resources.

(ii) The survey methods are relatively simple and easy to learn.

(iii) Because the methods are simple and easy to learn, the baseline survey and training component can be successfully implemented within the one week period available to the survey team (see above).

A summary of the survey procedures are given below.

2.2.1 *Invertebrates in the Shallow Habitat*

Surveys in the shallow habitat were done at depths between 1 – 4 m. Invertebrates surveyed included giant clams, trochus, pearl oysters (of Genus *Pinctada* & *Pteria*) and several species of sea cucumbers including lollyfish, surf redfish, orangefish and greenfish. Indicator species such as Crown of thorn star fish (*Acanthaster planci*), false trochus (*Tectus pyramis*) and Tritons (*Charonia tritonis*) were also recorded.

Sampling was done using 50 m long by 2 m wide transects. Six transects were laid haphazardly over the terrace at each site. Two teams of divers were involved in sampling. Table 2 gives the list of target invertebrates.

2.2.2 *Invertebrates in the Deep Habitat*

Surveys in the deep habitat were done at depths ranging from 14 – 30 m. The deep habitat included the slope below the terrace. In this habitat, only sea cucumbers were surveyed. However, the larger species of giant clams and pearl oysters were also recorded when encountered in transects.

Sampling was done using 50 m long by 5 m wide transects. Five transects were laid approximately parallel to the reef crest and over soft substratum or rubble (hard or rocky bottoms were avoided). Only one team of SCUBA divers was involved in sampling. Table 2 gives the full list of target invertebrates.

3.0 TRAINING

The first two days of the one week survey period was dedicated to training of local community representatives in target species identification (based on common English and Are'Are names) and sampling methods. The training on the sampling methodology also included land based demonstrations and field practical in laying transects and data recording. In addition to these, a brief outline of the survey rationale was also given to the participants.

Eight community representatives were trained. They were:

1) Paul Mamara'ai (Simeruka community)
2) Francis Mau (Simeruka community)
3) John Houakau (Simeruka community)
4) Lawrence Marai (Marapa community)
5) Calisto Pesoro (Marapa community)
6) Martin Uikaria (Marapa community - also FSPI/ECANSI Village Demonstration Worker)
7) Sylvester Puhuto (Marapa community)
8) Francis Kaomara (Marapa community)

4.0 DATA ANALYSIS

The data collected during this survey forms the baseline information for the two MPAs. Some statistical analysis maybe possible if another set of data is obtained in future surveys (after the formal declaration of the MPAs). At this stage, the baseline data have been interpreted graphically as follows.

Mean and standard errors for the species and variables were calculated for each of the two sites within the two MPAs and for all the sites within the reference areas. Graphs were then constructed for the MPAs sites for each variable. Basically, these graphs present baseline data for the MPAs sites compared to the reference sites.

5.0 RESULTS

5.1 Invertebrates in the Shallow Habitat

5.1.1 *Abundance of Invertebrates*

Results for seven species and variables sampled in the shallow habitat during the baseline survey are shown in Figures 2 – 8. The mean species abundance at the two sites within the proposed Marapa MPA (S1 & S2) and Simeruka MPA (S3 & S4) are greater than that of the reference area 1 sites (S5 & S6) and reference area 2 sites (S7 & S8) (Fig. 2). The Simeruka MPA sites, however, has the highest mean species abundance.

The mean abundance of sea cucumber for the sites within the proposed Marapa MPA (S1 & S2) is higher than that of the Simeruka MPA (S3 & S4) and both the reference area 1 (S5 & S6) and reference area 2 (S7 & S8) (Fig. 3). Only five species of sea cucumbers comprising 12 individuals were recorded in the shallow habitat (Table 3a). These were *Holothuria fuscogilva* (White teatfish), *Bohadschia marmoratus* (Tigerfish), *Holothuria edulis* (Pinkfish), *Pearsonothuria graeffei* (Orangefish) and *Thelenota ananas* (Prickly redfish). There was a lot of variation as indicated by the large error bars.

A mean of more than five giant clams per transect were recorded for the Simeruka sites (S3 & S4) as compared to four for Marapa (S3 & S4). The two reference areas (reference area 1- S5 & S6 and reference area 2 - S7 & S8) recorded less than three per transect (Fig. 4).

The most abundant giant clam species at the sites sampled were *Tridacna maxima* (Fig. 5) and *Tridacna crocea* (Fig. 6). There were more *T. maxima* at the Simeruka sites (S3 & S4) compared to Marapa (S1 & S2) and the reference area sites (S5 – S8). *T. crocea* was the most abundant single species for the baseline study. Both the Simeruka and Marapa MPAs sites recorded greater than 2.5 *T. crocea* per transect as compared to less than 2 in the reference areas. The numbers of *Tridacna derasa*, *Tridacna squamosa* and *Hippopus*

hippopus encountered during the survey was very low (Table 3a). *Tridacna gigas* was never recorded.

Overall, the total number of *Trochus niloticus* recorded during the survey was very small (Fig. 7). There were more *T. niloticus* in the reference areas (S5 – S8) compared to the two proposed MPAs (S1 – S4). With the exception of Sites S2 (Wainipareo) and S7 (Waitotono), the false trochus (*Tectus pyramis*) was found at higher abundance than *T. niloticus* (Table 3a).

The number of blacklip oyster (*Pinctada margaritifera*) recorded during this survey was greater than that of *T. niloticus*. Simeruka MPA (S3 & S4) recorded the highest numbers compared to Marapa (S3 & S4) and the reference areas (S5 – S8) (Fig. 8).

Greensnail (*Turbo marmoratus*) was not recorded during the survey and the crown of thorn starfish (*Acanthaster planci*) was encountered only in the Marapa MPA at site S2 (Wainipareo).

5.1.2 *Size Frequency Distribution*

Comparison of size frequency distribution among the two MPA sites and the Reference sites is limited by the relatively small sample sizes. The number of individuals measured in the shallow habitat were very small (n > 50), making it difficult to detect (statistically) any change in exploited invertebrates across times and spatial scales (Lincoln-Smith and Bell, 1996).

A combined total for all sites of 97 *Tridacna crocea* and 50 *Tridacna maxima* with mean sizes of 9 cm (range 6 – 15 cm) and 18 cm (range 8 – 28 cm) respectively were recorded (Table 3). The mean size of the 9 *Trochus niloticus* recorded was 9 cm (range 8 – 13cm). The mean size of the 5 *T. squamosa* recorded was 30 cm (range 24 – 38 cm)

5.2 Invertebrates in the Deep Habitat

5.2.1 *Abundance of Invertebrates*

Results for four species and evariables sampled in the deep habitat during the baseline survey are given in Figures 9 – 12.

Except for reference area 1 (D5 & D6), there was little difference in the mean abundance of the number of species recorded at the other three groups (Marapa: D1 & D2, Simeruka: D3 & D4 and reference area 2: D7 & D8) (Fig. 9). Large error bars indicate there was a lot of variation.

Except for reference area 1, the mean abundance of sea cucumber were also relatively similar within the other three groups (Marapa: D1 & D2 Simeruka: D3 & D4 and the reference area 2: D7 & D8) (Fig. 10). Only four species of sea cucumber comprising 19 individuals were recorded in the deep habitat. These were *Holothuria fuscogilva* (White teatfish), *Holothuria edulis* (Pinkfish), *Pearsonothuria graeffei* (Orangefish) and *Thelenota anax* (Amberfish).

White teatfish was only recorded at Marapa MPA and reference area 2 (Fig. 11). There was a lot of variation as indicated by the large error bars in the abundance of white teatfish within these two groups. No white teatfish were recorded at Simeruka MPA and reference area 1.

No pinkfish were recorded at reference area 1 (D5 & D6). The mean abundance of pinkfish within the other three groups however, was similar (Fig. 12). There were a lot of variations between the sites as indicated by large error bars.

5.2.2 *Size Frequency Distribution*

Comparison of size frequency distribution among the two MPA sites and the Reference sites is limited by the relatively small sample sizes. The number of individuals measured in the deep habitat were very small (n > 50), making it difficult to detect (statistically) any change in exploited invertebrates across times and spatial scales (Lincoln-Smith and Bell, 1996).

However, all six white teatfish (Table 3) recorded in the deep habitat were equal or larger than 39 cm (range 39 – 43 cm).

6.0 DISCUSSION

In Solomon Islands, the majority of people live on or near the coast. There is limited good agricultural farm land (or land based income generating alternatives) and therefore coastal people have always relied on marine resources for their livelihood for generations. With a fast growing population and a high commercial value attached to many marine resources (e.g. grade A white teatfish beche-de-mer is currently fetching SBD230.00 per kg in Honiara), this high dependency is expected to increase further. At the same time, development in fishing gear technology (e.g. monofilament gillnets, waterproof torch lights, underwater breathing gears like SCUBA and Hookar, dynamites and chemicals) has improved fishermen’s efficiency markedly and in some cases, is resulting in destruction of important marine habitats like the coral reef. In the absence of a strong traditional authority (a situation although sad but is becoming a reality in many coastal communities), we have a perfect setting for uncontrolled exploitation of marine resources which ultimately may lead to over-exploitation of the very resources that the livelihood of coastal communities depend.

The Marapa and Simeruka communities of Marau recognize that their marine resources face a real risk of over-exploitation. For a long time, they observed that there has been a reduction in the abundance and size of their catches. The result of this baseline study has confirmed this observation. Stocks of exploited invertebrates in the study area are very small compared to studies done elsewhere. Table 4 lists the range of mean densities across the study groups (sites) for selected species of invertebrates and the mean and maximum densities reported in literature. The mean density range for the AMCA is also included.

Sea cucumber densities were extremely low in the study area. For example, two of the most valuable species of sea cucumber, *Holothuria fuscogilva* (white teatfish) and *Thelenota ananas* (prickly redfish) were present in mean densities of up to 2 individuals per hectare. This is very low compared to mean densities of up to 18 individuals per hectare reported by Preston (1993) for the two species. Lincoln-Smith and Bell (1996) reported mean densities of up to 16 individuals per hectare for white teatfish and 2 individuals per hectare for prickly redfish in the AMCA region.

Tridacna crocea was the most common species of giant clam recorded among all the study groups with densities ranging from 5 (Reference Area 1) to 24 per hectare (Simeruka MPA). Compared to mean densities reported in other studies, this is very low. Munro (1993) reported densities well over 3,000 individuals per hectare in French Polynesia. Lincoln Smith and Bell (1996) reported densities up to 175 individuals per hectare for the AMCA region. *Tridacna maxima* was the second most common giant clam species with mean densities of 2.5 (Reference Area 2) to 15 per hectare (Simeruka MPA). Again, this is very low compared to mean densities reported in other studies for the species. Munro (1993) reported well over 1000 individuals per hectare in French Polynesia while in the AMCA region, Lincoln-Smith and Bell (1996) reported densities of up to 194 per hectare. The densities of the other giant clam species such as *Tridacna derasa*, *T. squamosa* and *Hippopus hippopus* were also extremely low compared to densities reported in other studies. *T. derasa* was found in mean densities less than 1 per hectare, *T. squamosa* in mean densities less than 2 per hectare and *H. hippopus* in mean densities of 2 per hectare. Lincoln-Smith and Bell (1996) reported mean densities up to 56, 13 and 23 per hectare for these species respectively for the AMCA region. Similarly, Munro (1993) reported higher mean densities of 5, 400 and up to 39 per hectare for the three species respectively. In contrast, *Tridacna gigas* was not recorded at all in this study.

Trochus niloticus ranged in density from 0.8 to 2.5 individuals per hectare during this study. Compared to densities reported in literature, this is very low. Whilst Lincoln-Smith and Bell (1996) reported a mean density range of 4 to 38 individuals per hectare for the AMCA region, Nash *et. al.*, (1995) reported densities well over 2,500 individuals per hectare in the Cook Islands.

Although the stock densities of exploited invertebrates were quite small, the sizes of individuals measured indicated that most were mature adults. Munro (1993) cautioned however, that juveniles of some species are highly cryptic and can be overlooked. Munro (1993) reported that *T. maxima* and *T. squamosa* matured as males at 5 cm and as females at 6 – 8 cm and 15 cm respectively. The smallest *T. maxima* measured during this baseline study was 8 cm in size and the smallest *T. squamosa* was 22 cm. On this basis, all *T. maxima* and *T. squamosa* recorded during this study were adult females.

Not only that the number of individual sea cucumber measured during this study in both the shallow and deep habitats were very small, the number of species found were very low as well. In the deep habitat, a total of six white teatfish with lengths ranging from 39 to 43 cm were recorded. According to Preston (1993), white teatfish mature at 32 cm in size. On the basis of this, all six white teatfish measured during this study were mature individuals.

According to Nash (1993), trochus mature as males at 5 – 8 cm and females at 5 – 9 cm. The domestic legal harvest size range for trochus is 8 – 12 cm. The average size of all trochus recorded during this study was 9 cm (range 8 – 13 cm). On this basis, all trochus measured were both matured as adults and above the minimum legal size. Nash (1993) also reported the mean lengths of trochus at 2 years and 3 years to be 5.8 and 7.6 cm respectively. Based on this result, distinct cohorts of trochus > 8 cm may be observed in the MPAs but not the reference areas if the MPAs are successful.

The main expectation of the baseline study is to be able to detect change in realistic increase in abundance and size of commercially important invertebrates over time and at spatial scales. This is because: (1) low abundances were found prior to MPA declaration and (2) similar levels of variabilities in MPAs and reference areas.

A major concern would be that sample sizes for length frequency analysis may not be large enough to provide an appropriate test for any but the largest spatial scale considered, that is, Groups (MPAs & Reference Areas). Unlike the "before" and "after" or Beyond BACI procedures (Underwood, 1993) whereby a relationship is established before human impact, the relationship between the MPAs and reference areas in this case is established in the presence of human fishing activity. The impact of removal of fishing from the MPAs will be assessed through the "before" and "after" sampling regime. Two assumptions are therefore important: (1) no fishing in the MPAs and the level of fishing in the reference areas remain unchanged and (2) the conditions within the MPAs would be suitable to support an increase in number and size of invertebrates than occur there now in the absence of exploitation.

Lincoln-Smith and Bell (1996) highlighted that factors like larval supply and habitat characteristics affect the ability of MPAs to support exploited invertebrates.

Whilst there is limited information on the hydrodynamic conditions of the study area, it is expected that there would be sufficient supply of larvae to the group given the closeness of the MPAs to other reefs. Although there is limited information on the extent to which the invertebrates of interest may be affected by habitat, such information as reported by Nash (1993) regarding the recruitment of juvenile trochus, may be useful in providing a measure of differences among sites and groups.

The mean densities of trochus and other exploited invertebrates recorded during this study is very low that it may not be meaningful to define the relationship between density or size and habitat using the “before” and “after” monitoring regime. Some knowledge of the habitat structure may be useful though to explain any patterns of variation seen after the MPAs have been in place for a number of years.

7.0 CONCLUSION

Overall, this baseline study has established the following:

(1) The number of important (commercial & subsistence) invertebrate species in the Marau study area (MPAs & Reference Areas) is alarmingly very low – even lower than the lowest reported elsewhere. The time is right for management intervention (by community leaders) to control the exploitation of these resources. The establishment of MPAs by local communities in Marau for the conservation and enhancement of marine resources is a good start. This initiative must be supported by the government and other partners in the Coral Gardens Project.

(2) Sea cucumber species, especially those of high commercial value, Trochus and the larger species of giant clams (*Tridacna gigas, T. derasa* and *T. squamosa*) are heavily exploited resulting in the low abundance of these animals. *T. crocea* and *T. maxima* are also heavily exploited. *T. gigas* is probably on the verge of extinction from the study area. All invertebrates recorded during this baseline study were mature adults.

(3) The success of the MPAs will depend on the communities respecting their own initiative and ensuring no fishing activity takes place within the MPAs (i.e. no poaching!). At the same time, fishing activities within the Reference Areas must not change. Partner support for this community initiative will also be necessary to ensure community commitment and interest.

(4) The pearl oyster Blacklip (*Pinctada margaritifera*) was found in higher abundance compared to Trochus. This many be a direct effect of a Fisheries Department (Government) Regulation banning the harvest and commercial trading, including the export of the species which has been in force since the early 1990s. Communities should respect this Regulation.

(5) Coral damage from crown of thorn starfish (*Acanthaster planci*) in the study area is very minimal. Fishermen in Marau do not use dynamite and chemicals (including traditional ones) for fishing.

8.0 RECOMMENDATION

As highlighted above, MPAs serve many purposes and can be used as a marine resource management tool to provide many benefits to the communities. The establishment of the Marapa and Simeruka MPAs by the owning communities is a major step towards the management and conservation of their marine resources. As such, it will be of paramount importance that the communities respect their MPAs. At the same time, the support from other stakeholders (FSPI, ECANSI, DEPT. OF FISHERIES) for this community initiative is crucial.

In light of the importance of these two community MPAs and the results of this baseline survey, the following are recommended.

(a) The communities must be assisted through annual surveys of their MPAs so that additional sets of data are made available for comparison of numbers and sizes of invertebrates before and after declaration thus determining the success or effectiveness of their MPAs. Through such surveys, community interest will be maintained. The participation of more members of the Solomon Islands Locally Managed Marine Area (SILMMA) partners in this FSPI initiative in future is desirable and recommended.

(b) To cater for full participation of community representatives in monitoring surveys (and other marine surveys which may be requested by the communities), suitable community representatives must be SCUBA trained if possible. In the long term, communities should be responsible for all aspects of monitoring their own MPAs and therefore they should be assisted where possible. This is a request from the communities. In future, the possibility of monitoring other marine resources and habitats such as Fish, Corals and Seagrass must also be considered.

(c) Maintaining a regular communication link with the communities is very important. The possibility of installing radio for communication in the communities should be considered

(d) It is important that the result of this baseline survey and future surveys must be taken back to the communities.

(e) The Coral Gardens Project should provide masks and fins for use by community representatives during MPA monitoring surveys especially at the initial stages of project implementation.

(f) The Project must meet the DAN Insurance (Diving Insurance) expenses of all personnel involved in SUCBA diving. The Project must also pay whoever has compiled trip report upon completion.

9.0 ACKNOWLEDGEMENT

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Table 1(a): A general description of the sampling sites

SHALLOW HABITAT			
GROUP/ISLAND	**LOCALITY**	**SITE**	**SITE DESCRIPTION**
Marapa MPA	Su'uirawa	S1	Marapa Is. Reef terrace west of tambu area
	Wainipareo	S2	Marapa Is. Shallow reef off Wainipareo stream (in the bay)
Simeruka MPA	Roaroa	S3	Sand/rubble/coral habitat off Peura Is. Approx. 200 m from black rocks
	Arearesau	S4	Sand/coral/rubble off Simeruka Is. Approx. opposite eastern tip.
Reference Area 1	Awanararu	S5	Reef terrace on eastern side of Awaniraru passage
	Niu	S6	Sand/coral/rubble off Niu Is.
Reference Area 2	Waitotono	S7	Marapa Is. Narrow reef shelf between Wainipareo stream and Hon. James village
	Tawanipo	S8	Marauiapa Is. Narrow fringing reef to the south of Tambu site.
DEEP HABITAT			
Marapa MPA	Su'uirawa	D1	Marapa Is. Reef slope to the west of Tambu area
	Wainipareo	D2	Marapa Is. Reef slope off S2 in the bay
Simeruka MPA	Roaroa	D3	Reef slope off S3 on Peura Island
	Arearesau	D4	Reef slope off S4 approx. opposite eastern tip of Simeruka Is.
Reference Area 1	Awanararu	D5	Reef slope, begin opposite point and work back to the Awaniraru passage
	Niu	D6	Niu Is. Reef slope off S6
Reference Area 2	Waitotono	D7	Marapa Is. Reef slope off S7
	Tawanipo	D8	Marauiapa Is. Reef slope off S8

Table 1(b): Latitude and longitude for each sampling site, measured using a Global Positioning System (GPS)

GROUP/ISLAND	LOCALITY	SITE	LAT. (South)	Long. (East)
SHALLOW HABITAT				
Marapa MPA	Su’uirawa	S1	09^o 50.30’	160^{o}51.72’
	Wainipareo	S2	09^o 48.86’	160^{o}51.83’
Simeruka MPA	Roaroa	S3	09^o 48.54’	160^{o}50.39’
	Arearesau	S4	09^o 49.06’	160^{o}50.56’
Reference Area 1	Awaniraru	S5	09^o 50.21’	160^{o}52.32’
	Niu	S6	09^o 50.83’	160^{o}51.51’
Reference Area 2	Waitotono	S7	09^o 48.22’	160^{o}51.41’
	Tawanipo	S8	09^o 48.03’	160^{o}49.74’
DEEP HABITAT				
Marapa MPA	Su’uirawa	D1	09^o 50.25’	160^{o}51.60’
	Wainipareo	D2	09^o 48.76’	160^{o}51.77’
Simeruka MPA	Roaroa	D3	09^o 48.53’	160^{o}50.39’
	Arearesau	D4	09^o 49.04’	160^{o}50.59’
Reference Area 1	Awaniraru	D5	09^o 50.32’	160^{o}52.49’
	Niu	D6	09^o 50.83’	160^{o}51.53’
Reference Area 2	Waitotono	D7	09^o 48.35’	160^{o}51.45’
	Tawanipo	D8	09^o 48.13’	160^{o}49.08’

Table 2: List of target invertebrates for this baseline survey.

TAXA	**COMMON NAME**	**SPECIES**
Sea cucumbers	Deepwater redfish	*Actinopyga echinites*
Sea cucumbers	Stonefish	*Actinopyga lecanora*
Sea cucumbers	Surf redfish	*Actinopyga mauritiana*
Sea cucumbers	Blackfish	*Actinopyga miliaris*
Sea cucumbers	Tiger/Leopardfish	*Bohadschia argus*
Sea cucumbers	Chalkfish/false Teatfish	*Bohadschia similes*
Sea cucumbers	Brown sandfish	*Bohadschia vitiensis*
Sea cucumbers	Lollyfish	*Holothuria atra*
Sea cucumbers	Snakefish	*Holothuria coluber*
Sea cucumbers	Pinkfish	*Holothuria edulis*
Sea cucumbers	White Teatfish	*Holothuria fuscogilva*
Sea cucumbers	Elephant’s trunkfish	*Holothuria fuscopunctata*
Sea cucumbers	Black Teatfish	*Holothuria nobilis*
Sea cucumbers	Sandfish	*Holothuria scabra*
Sea cucumbers	Orange/flowerfish	*Bohadschia graeffei*
Sea cucumbers	Greenfish	*Stichopus chloronotus*
Sea cucumbers	Dragonfish	*Stichopus horrens*
Sea cucumbers	Curryfish	*Stichopus variegates*
Sea cucumbers	Prickly redfish	*Thelenota ananas*
Sea cucumbers	Amberfish	*Thelenota anax*
Pearl Oysters	Gold lip pearl oyster	*Pinctada maxima*
Pearl Oysters	Blacklip pearl oyster	*Pinctada margaritifera*
Pearl Oysters	Brown pearl oyster	*Pteria penquin*
Giant clams	Giant clam	*Tridacna gigas*
Giant clams	Smooth giant clam	*Tridacna derasa*
Giant clams	Fluted giant clam	*Tridacna squamosa*
Giant clams	Rugose giant clam	*Tridacna maxima*
Giant clams	Burrowing giant clam	*Tridacna crocea*
Giant clams	Horseshoe clam	*Hippopus hippopus*
Lobsters	Double spined rock lobster	*Panulirus penicillatus*
Lobsters	Painted rock lobster	*Panulirus versicolor*
Lobsters	Ornate rock lobster	*Panulirus ornatus*
Lobster	Slipper lobster	*Paribaccus caledonicus??*
Snails	Trochus	*Trochus niloticus*
Snails	False Trochus	*Pyramis tectus*
Snails	False Trochus	*Trochus maculates*
Snails	Greensnail	*Turbo marmoratus*
Snails	Triton*	*Charonia tritonis*
Starfish	Crown of Thorns*	*Acanthaster planci*

* Indicator species coral reef health

Table 3(a): Total number of invertebrates found within transects in the shallow habitat

INVERTEBRATE SPECIES	TOTAL NUMBER FOUND	AVERAGE SIZE (CM)
Giant clams		
T. gigas	0	-
T. derasa	1	-
T. squamosa	5	30 (range 24-38cm)
T. maxima	50	18 (range 8-28cm)
T. crocea	97	9 (range 6-15cm)
H. hippopus	5	
Trochus and Greensnail		
T. niloticus	9	9 (range 8-13cm)
Tectus pyramis	73	-
Turbo marmoratus	0	-
Pearl Oyster		
P. margaritifera	14	14 (range 12-16)
P. maxima	0	-
P. penquin	0	-
Sea cucumber		
H. fuscogilva	2	-
H. edulis	4	-
H. graeffei	2	-
B. marmoratus	1	-
T. ananas	3	-
Others		
A. planci	2	-
Triton	0	-

Table 3(b): Total number of sea cucumbers recorded in the deep habitat

SEA CUCUMBER SPECIES	TOTAL NUMBER FOUND	AVERAGE SIZE (CM)
H. fuscogilva	6	40 (range 39 – 43)
H. edulis	9	26 (range 20 – 37)
H. graeffei	3	-
T. anax	1	-

*Table 4: Comparison of densities of exploited invertebrates recorded during this study with estimates for other Indo Pacific Islands. nd = no data; * indicates no differentiation between deep and shallow habitats; '*' mean density range for the Arnavon MPA reported by Lincoln-Smith & Bell, 1996*

Invertebrate species			**Reported densities**		**Reference**
	Range of Mean densities for this study area (MPA & Reference sites) (No./ha)	**Range of Mean densities for AMCA region (No./ha)'*'**	**Mean density (No./ha)**	**Maximum density (No/ha)**	
Giant clams (shallow)					
Tridacna crocea	5 – 24	0 – 175	1390	>3000	Munro 1993
Tridacna maxima	2.5 – 15	98 – 194	nd	>1000	Munro 1993
Tridacna squamosa	0 – 1.7	0 -13	400	nd	Mohamed-Pauzi et al., 1994
Tridacna derasa	0 – 0.8	0 – 56	5	33	Munro 1993
Tridacna gigas	0	0 – 10	5	50	Munro 1993
Hippopus hippopus	0 – 2.1	0 – 23	30 - 39	nd	Munro 1993
Sea cucumber (shallow & deep habitat)					
Holothuria fuscogilva(deep)	0 – 1.6	3.2 – 16	11 – 18.4	43 – 81.7	Preston 1993
Holothuria fuscopunctata(deep)		1.6 – 13.2	22	106	Preston 1993
Holothuria nobilis(deep)		0 – 0.8	13 – 18.7*	43 – 275*	Preston 1993
Holothuria nobilis(shallow)		0 – 2	"	"	Preston 1993
Holothuria atra(deep)		3.2 – 36	545*	7270*	Preston 1993
Holothuria atra(shallow)		0 – 42	"	"	Preston 1993
Stichopus chloronotus(shallow)		0 – 31	nd	4258	Preston 1993
Stichopus variegatus(deep)		0.8 – 8.4	nd	456	Preston 1993
Thelenota ananas(deep)		0 – 1.6	16.8 – 18*	31.4 – 141*	Preston 1993
Thelenota ananas(shallow)	0 – 2.1	0 – 2	"	"	Preston 1993
Thelenota anax(deep)	0 – 0.4	2.4 – 15.2	41*	241*	Preston 1993
Thelenota anax(shallow)		0 – 2	"	"	Preston 1993
Actinopyga mauritaniana(shallow)		0 – 17	nd	304	Preston 1993
Actinopyga miliaris(deep)		0 – 2.4	512*	5970 – 78900*	Preston 1993
Actinopyga miliaris(shallow)		0 – 2	"	"	Preston 1993
Trochus (shallow habitat)					
Trochus niloticus	0.8 – 2.5	4 – 38	222 – 2016	2775	Nash et al., 1995
				1290	Tsutsui & Sigrah 1994
			62 - 590	nd	Long et al., 1993
Pearl oyster (shallow habitat)					
Pinctada margaritifera	0.8 – 4.2				

FIGURE 1: Map of study area showing MPAs and approximate location of sites.

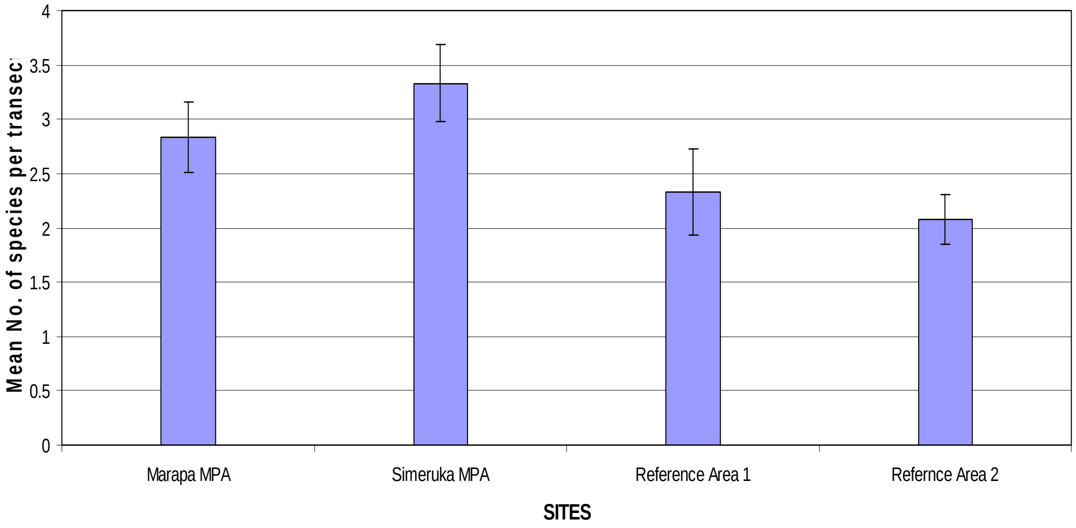

Figure 2: Mean number (+/- SE, n=12) of species for two sites within Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and references areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow habitat

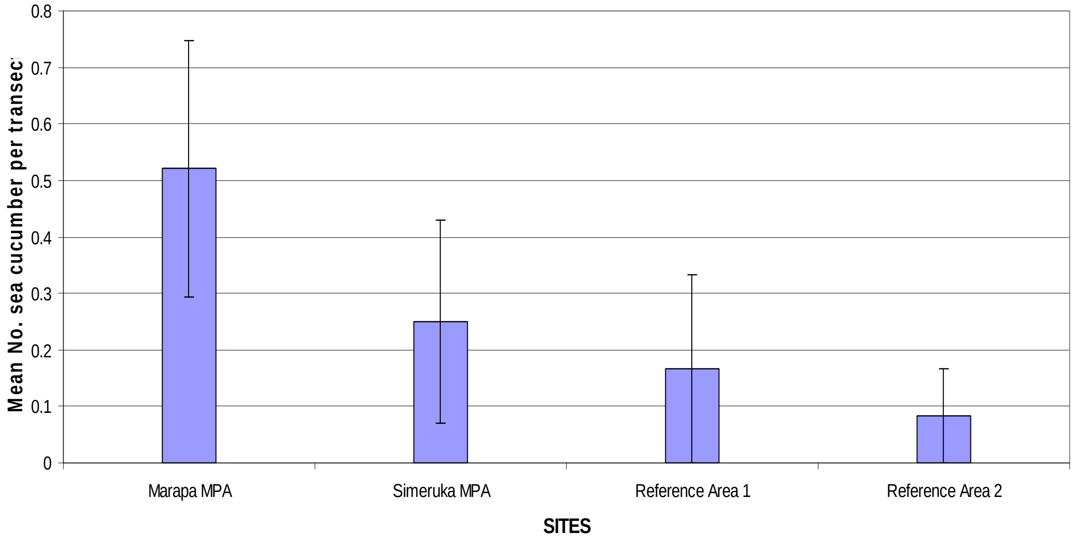

Figure 3: Mean number (+/- SE; n=12) of sea cucumber for two sites within Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and reference areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow habitat

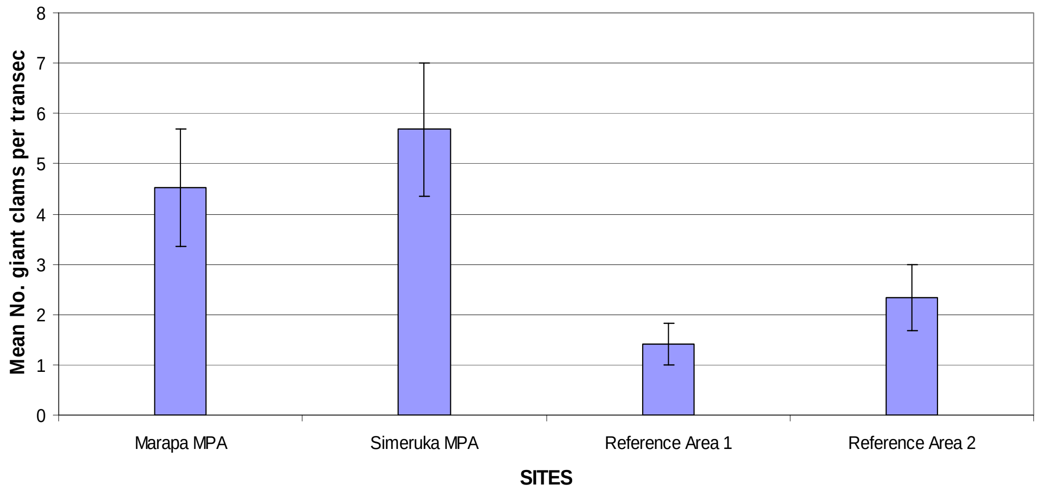

Figure 4: Mean number (+/- SE;n=12) of giant clams for the two sites within the Marapa MPA (S1 & S2), the two sites within the Simeruka MPA (S3 & S4) and reference areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow habitat

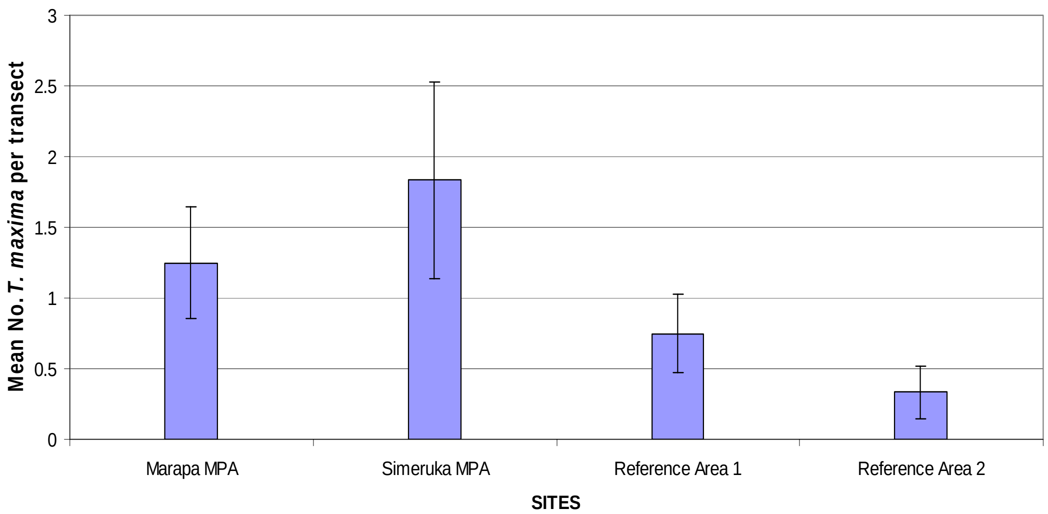

Figure 5: Mean number (+/- SE; n=12) of *Tridacna maxima* for two sites within Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and reference areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow habitat

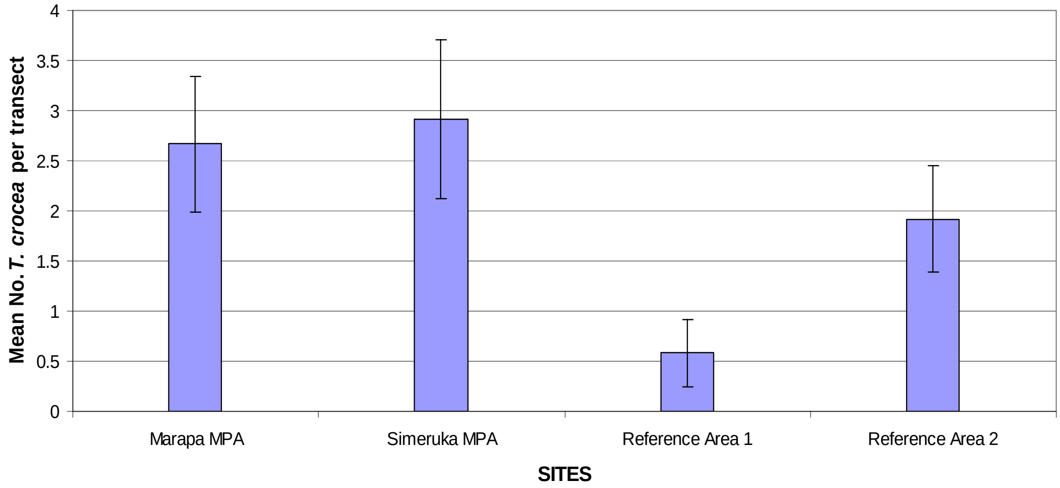

Figure 6: Mean number (+/- SE; n=12) of *Tridacna crocea* for the two sites within Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and reference areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow Habitat

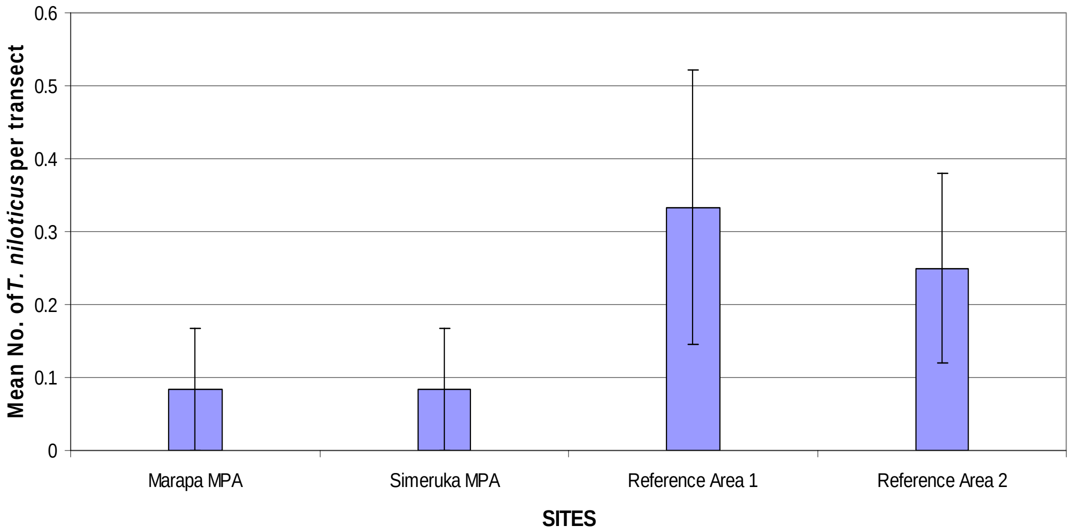

Figure 7: Mean number (+/- SE; n=12) of *Trochus niloticus* for the two sites within the Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and reference areas (Ref. 1 (S5 & S6) & Ref. 2 (S7 & S8)) in shallow habitat

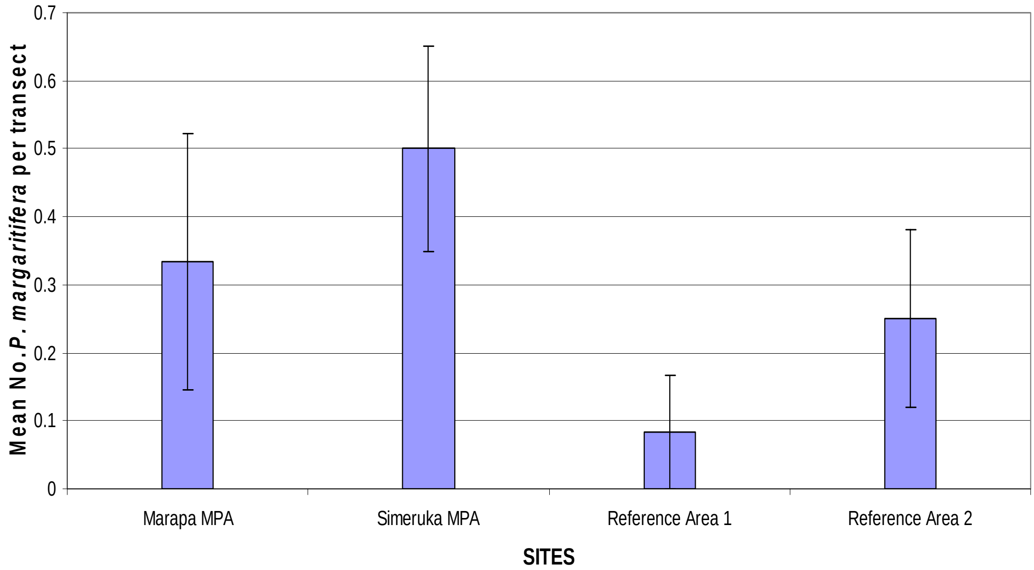

Figure 8: Mean number (+/- SE; n=12) of *Pinctada margaritifera* (Blacklip oyster) for two sites within Marapa MPA (S1 & S2), two sites within Simeruka MPA (S3 & S4) and reference areas (Ref. area 1 (S5 & S6) & Ref. area 2 (S7 & S8)) in shallow habitat.

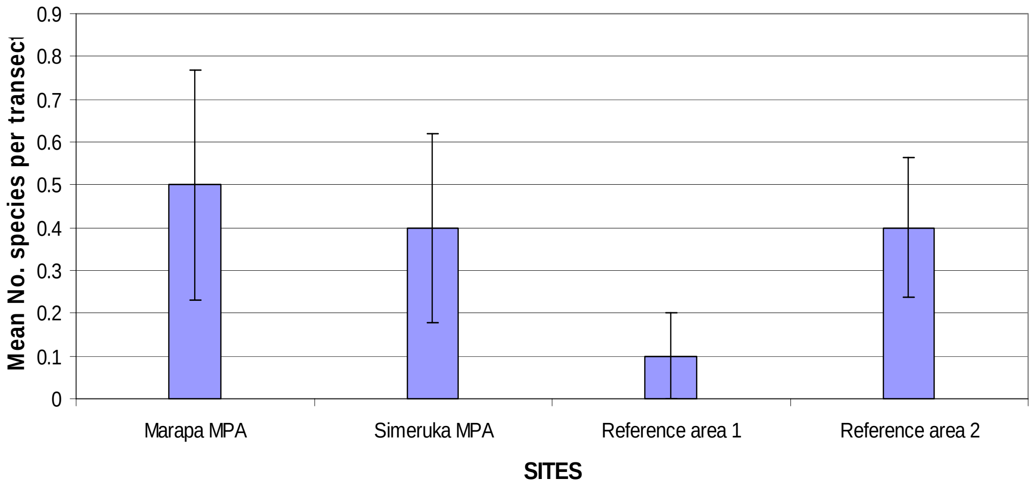

Figure 9: Mean number (+/- SE; n=10) of species for the two sites within the Marapa MPA (D1 & D2), two sites within the Simeruka MPA (D3 & D4) and references areas (Ref. 1 (D5 & D6) & Ref. 2 (D7 & D8)) in the deep habitat

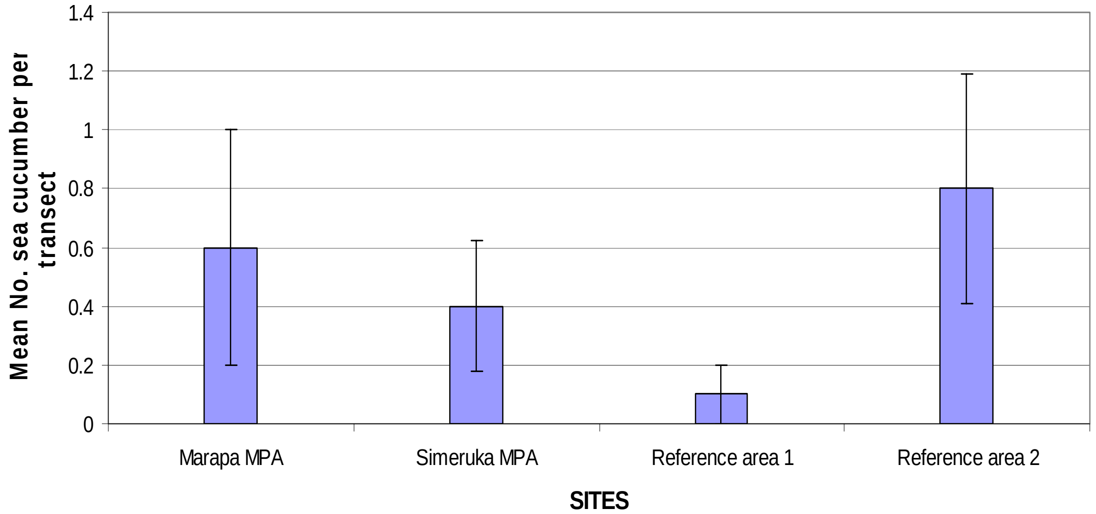

Figure 10: Mean number (+/- SE; n=10) of sea cucumber for two sites within the Marapa MPA (D1 & D2), two sites within the Simeruka MPA (D3 & D4) and reference areas (Ref. 1 (D5 & D6) & Ref. 2 (D7 & D8)) in the deep habitat

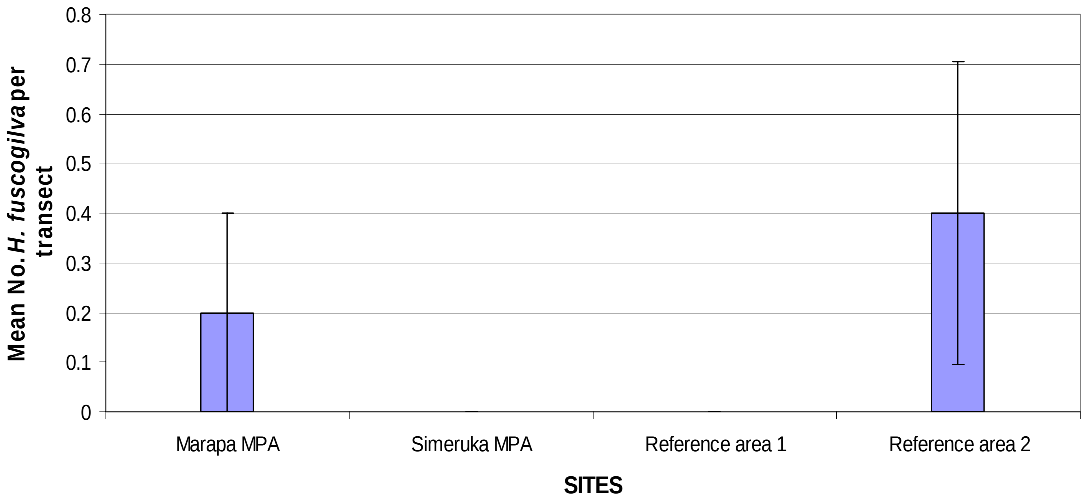

Figure 11: Mean number (+/- SE; n=10) of *Holothuria fuscogilva* for the two sites within the Marapa MPA (D1 & D2), two sites within Simeruka MPA (D3 & D4) and reference areas (Ref. 1 (D5 & D6) & Ref. 2 (D7 & D8)) in the deep habitat

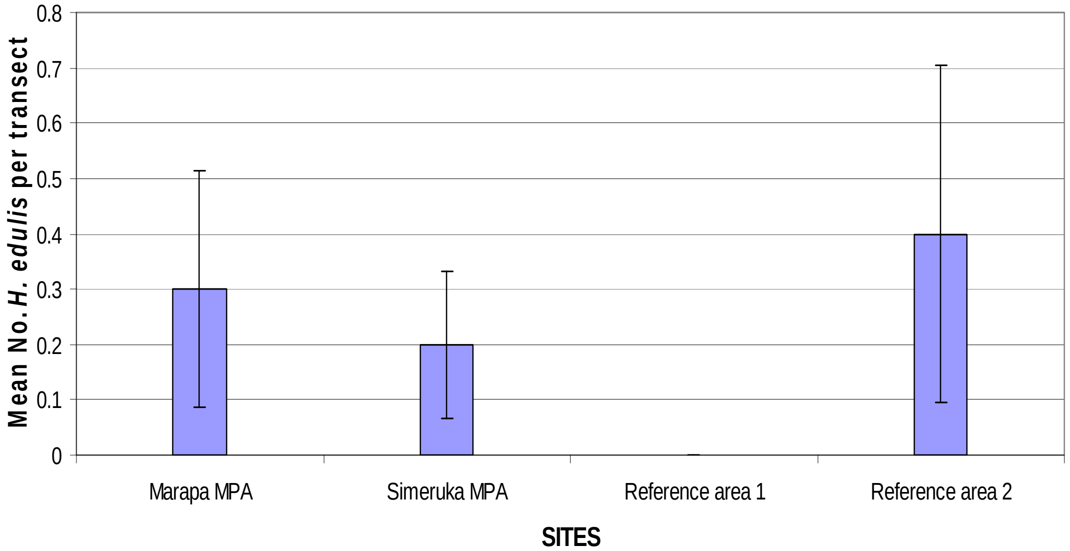

Figure 12: Mean number (+/- SE; n=10) of *Holothuria edulis* (pinkfish) for the two sites within the Marapa MPA (D1 & D2), two sites within the Simeruka MPA (D3 & D4) and & Reference Areas (Ref. 1 (D5 & D6) & Ref. 2 (D7 & D8)) in the deep habitat