Abundance of commercially important species of invertebrates in the Sisili and Taburu Community-Based Marine Protected Areas in Ngella, July 2004

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SUMMARY

A team comprising personnel from the Foundation of the South Pacific Peoples International (FSPI), Department of Fisheries and Marine Resources (DFMR), The Nature Conservancy (TNC) and the International Waters Programme (IWP) visited the Leitongo community from 23rd to 26th July, 2004. During this trip, a number of activities were undertaken by the team. These activities included: (a) a baseline survey on commercially important marine invertebrates of the Sisili and Taburu community-based Marine Protected Areas (MPAs) (b) training of selected community representatives on species identification (invertebrate species) and survey methods and (c) undertaking education and awareness activities within the Leitongo community.

The baseline survey of commercially important 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 five in the deep at each study site. 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 the study area is low compared to what is reported in other parts of the Solomon Islands and the South Pacific region. Sea cucumber abundance is low both in the shallow and deep habitats. Only 11 of the commercially known sea cucumber species in the Solomon Islands were recorded during this survey. In the shallow habitat, the mean density of sea cucumbers ranged from 0 - 1.00 per transect (100m^2) or equivalent of 0 - 100 per hectare. The low valued species, Pinkfish (*Holothuria edulis*), was the most abundant sea cucumber species in this habitat with densities up to 0.83 per transect or equivalent to 83 per hectare. In the deep habitat, the mean density of sea cucumbers ranged from 0.8 - 3.60 per transect (250m^2) or equivalent to 32 -144 per hectare respectively. Pinkfish and white teatfish (*Holothuria fuscogilva*) were the most abundant species in this habitat with densities up to 2.60 per transect for the former and 0.80 for the latter respectively or equivalent to 104 and 32 animals per hectare.

In the shallow habitat, giant clam abundance is low as well. Giant clam abundance ranged from 0.33 – 6.00 per transect or equivalent to 33 – 600 per hectare. *Tridacna crocea* was the most

abundant clam species with densities ranging from 0 – 4.33 per transect or equivalent to 0 – 433 per hectare. The larger species such as *T. gigas* and *T. derasa* were not seen in the study area. Trochus (*Trochus niloticus*) was also not recorded during the study. Blacklip pearl oyster (*Pinctada margaritifera*) was found in low numbers as well. The shell-money species Ke'e (*Beguina semiorbiculata*) was the most abundant bivalve species in the shallow habitat with mean densities ranging from 0 – 9.67 per transect or equivalent 0 – 967 per hectare. A number of conclusions were made to highlight these and other results found during this baseline survey.

This baseline study is designed to compare "before" and "after" declaration data for the two community-based MPAs and this should enable the community owning the Sisili and Taburu MPAs to determine the success of these two MPAs.

1.0 INTRODUCTION

The purpose and potential benefits of MPAs are numerous and are discussed by many authors as outlined by Ramohia, 2004 while the effectiveness of an MPA in Solomon Islands was demonstrated at the Arnavon Marine Conservation Area (AMCA) by Lincoln-Smith et al., 2000. Briefly, the potential benefits of MPAs 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 Solomon Islands Locally Managed Marine Areas (SILMMA) network was established in November 2003 and through this network, the government, FSPI, TNC, IWP, WWF (World Wide Fund for nature) and other non-government organizations (NGOs) are working closely with local communities in the country, including Marau in Guadalcanal Province, Ngella in the Central Islands Province and Langalanga in Malaita Province to promote and improve management and sustainable use of coastal marine resources. Management measures being promoted include MPA establishment, ban on destructive fishing methods and resource enhancement trials.

Two community-based and managed MPAs have now been established in Marau (Ramohia, 2004) by the Marapa and Simeruka communities. Three more have being established by the Leitongo and Maravaghi communities on Ngella. It is anticipated that more MPAs will be established through this network in Ngella, Langalanga lagoon and Marau in future.

A survey team comprising personnel from SILMMA partner organizations (FSPI, DFMR, TNC and IWP), visited the Leitongo community on Ngella from 23rd to 26th July and undertook a baseline survey on key commercially important marine invertebrate species of their two proposed MPAs of Sisili and Taburu. At the same time, the team provided training to community representatives in the monitoring methodology used during the baseline.

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 and
e) education and awareness raising

This report presents the result of the baseline survey carried out for the two proposed community-based MPAs.

2.0 METHOD

2.1 Study Sites

The study sites for this baseline survey consisted of two MPAs (Sisili and Taburu) and three reference areas (Rodrigue bay, Tulagi Island and Darwin reef) and are given in Figure 1. The MPAs and the reference areas are located in the vicinity of Leitongo village within the Sandfly passage on Ngella. Like in the case of the Marau MPAs (Ramohia, 2004), the people of Leitongo community themselves were responsible for selecting and demarcating the boundaries of the two

MPAs. Detail information on the study sites and their exact coordinates are given Tables 1a and 1b.

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) The survey methods best used when monitoring important commercial marine invertebrates and these are the resources requested by the community to be assisted in monitoring.

(ii) These 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.

A summary of the survey procedures and methods 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 (*Trochus niloticus*), pearl oysters (of Genus *Pinctada* & *Pteria*) and several species of sea cucumbers including lollyfish (*Holothuria atra*), surf redfish (*Actinopyga mauritiana*), orangefish (*Pearonothuria graffei*) and greenfish (*Stichopus chloronotus*). 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 invertebrate species surveyed.

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 list of invertebrate species surveyed.

3.0 TRAINING

The first day of the one week survey period was dedicated to training of local community representatives in identification of target or key invertebrate species (based on common English and local dialect names) and sampling methods. The training on the sampling methodology included land based demonstration 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 trainees. The community trainees are given in Table 3.

4.0 DATA ANALYSIS

No statistical analysis was performed on the baseline data collected for the two MPAs. However, the data have been interpreted graphically as follows.

Mean and standard errors (±SE) for the species and variables were calculated for the two sites within the two MPAs and for the sites within the three reference areas (see Figure 1). Graphs were then constructed for the MPAs and reference areas for each species and composite variable. These graphs allow for easy comparison between the MPAs and reference areas.

5.0 RESULTS

5.1 General

During the baseline survey, 11 species of sea cucumbers, 8 species of bivalves (giant clams and oyster shells) and two trochus-like species (*Tectus pyramis* and *Trochus maculatus*) were encountered (Table 4). However, some species like *Trochus niloticus*, the gold lip pearl oyster (*Pinctada maxima*), greensnail (*Turbo marmoratus*) or the coral predator crown of thorn (*Acanthaster planci*) were not observed in the study sites.

Species of commercially important invertebrates occurred in varying numbers not only in the two habitats surveyed (shallow and deep) but also at the different sites (MPAs and reference areas). For example, although the shallow habitat has more species of invertebrates than the deep, the deep habitat actually recorded more species of sea cucumber than the shallow habitat. Also, overall, the Rodrigue bay reference area recorded more species of commercially important invertebrates than all the other sites surveyed.

The rest of this Section provides more detail on the key marine invertebrate species.

5.2 Invertebrates in the Shallow Habitat

Results for sixteen species and composite variables from the shallow habitat are shown in Figures 2 to 17. The mean number of species of commercially important invertebrates ranged from 1.17 (±0.40) at Tulagi Island reference area to 3.83(±0.48) at Rodrigue bay reference area (Fig. 2). Sisili and Taburu MPA sites recorded 1.33 (±0.33) and 3.17 (±0.54) respectively while Darwin reef, another reference area, recorded 2.00 (±0.37) (Fig. 2).

The mean number of all sea cucumbers ranged from zero at Darwin to 1.00 (±0.63) at Rodrigue bay and 1.00 (±0.37) at Tulagi Island while the two MPAs, Sisili and Taburu, recorded 0.17 (±0.17) and 0.33 (±0.33) respectively (Fig. 3). Only four species of sea cucumbers comprising 15 individuals were recorded in the shallow habitat. These were brown curryfish (*Stichopus vastus*), tigerfish (*Bohadschia marmoratus*), pinkfish (*Holothuria edulis*) and orangefish (*Pearsonothuria graeffei*).

Rodrigue bay recorded the highest mean number of giant clams per transect with 6.00 (±1.63) compared to Taburu with 4.33 (±1.41) and Sisili 3.00 (±1.63) (Fig. 4). Tulagi Island and Darwin reef recorded 0.33 (±0.33) and 0.67 (±0.33) respectively (Fig. 4).

The mean number of all commercially important invertebrates ranged from 1.50 (±0.43) at Tulagi Island to 11.00 (±3.25) at Darwin (Fig. 5). While Rodrigue bay recorded the second highest with 10.67 (±3.24), Sisili and Taburu recorded 10.33 (±2.50) and 9.33 (±4.18) respectively (Fig. 5). These high mean numbers was attributed to the high counts of the shell-money species ke'e (*Beguina semiorbiculata*) recorded at these study sites.

The most abundant giant clam species at the sites sampled was *Tridacna crocea* (Fig. 6). Mean numbers of this species ranged from zero per transect at Tulagi Island to 4.33 (±1.31) at Rodrigue bay. Sisili and Taburu recorded 3.00 (±1.63) and 2.17 (±1.08) respectively while Darwin 0.33 (±0.21) (Fig. 6). *T. maxima* was not encountered at Sisili and Tulagi Island but were recorded at Taburu, Rodrigue bay and Darwin with mean numbers of 1.83 (±0.60), 1.50 (±0.62) and 0.33 (±0.33) respectively (Fig. 7). *T. squamosa* was only observed at Tulagi Island and Rodrigue bay with mean numbers of 0.33 (±0.33) and 0.17 (±0.17) respectively (Fig. 8) while *Hippopus hippopus* was only encountered at Taburu with a mean number of 0.33 (±0.21) per transect (Fig. 9). *T. gigas* and *T. derasa* were not recorded during the survey.

The blacklip pearl oyster (*Pinctada margaritifera*) was recorded only at Rodrigue bay and Darwin reef with mean numbers of 0.50 (±0.22) and 0.33 (±0.21) respectively (Fig. 10) and the false trochus *Tectus pyramis* was only encountered at Rodrigue bay, Tulagi Island and Darwin with mean numbers 0.33 (±0.33) or less (Fig. 11). *Trochus niloticus* was not seen at all during the survey.

The most abundant species of the commercially important invertebrate was *B. semiorbiculata* or ke'e as locally known. This species is used for making custom shell-money. The species was recorded with mean numbers ranging from zero at Tulagi Island to 9.67 (±3.13) at Darwin reef (Fig. 12). Sisili, Taburu and Rodrigue bay all recorded mean numbers of 7.17 (±2.47), 4.17 (±3.20) and 2.83 (±1.45) respectively (Fig. 12). On the other hand, the other shell-money species *Atrina vexillum* (kurila) was only encountered at Taburu and Rodrigue bay with mean numbers 0.17 (±0.17) or less (Fig. 13).

Greensnail (*Turbo marmoratus*) and the crown of thorn starfish (*Acanthaster planci*) were not seen during the survey.

Pinkfish (*Holothuria edulis*) was the most common and abundant species of sea cucumber in the shallow habitat (Fig. 14). The species was recorded with mean numbers of zero at Darwin to 0.83 (±0.31) at Tulagi Island. Sisili, Taburu and Rodrigue bay all recorded 0.17 (±0.17) respectively (Fig. 14). Tigerfish (*B. argus*) was only seen at Tulagi Island with a mean number of 0.17 (±0.17) (Fig. 15), orangefish (*Pearsonothuria graeffei*) at Rodrigue bay with 0.83 (±0.65) (Fig. 16) and the brown curryfish (*Stichopus vastus*) at Taburu with a mean number of 0.17 (±0.17) (Fig. 17).

5.2.1 *Size Frequency Distribution*

Comparison of size frequency distribution among the 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). However, the average size of the giant clams, pearl oysters and sea cucumber species found in the shallow habitat are given in Table 5.

5.3 Invertebrates in the Deep Habitat

Results for thirteen species and composite variables from the deep habitat are given in Figures 18 – 31. The mean number of commercially important species in the deep habitat ranged from 0.20 (±0.20) at Darwin to 2.20 (±0.58) at Rodrigue bay (Fig. 18). Sisili and Taburu MPAs recorded 1.40 (±0.24) and 1.60 (±0.60) respectively while Tulagi Island 1.60 (±0.24) (Fig. 18).

The mean number of all sea cucumbers ranged from 0.80 (±0.80) at Darwin to 3.60 (±1.03) at Rodrigue bay (Fig. 19). The two MPAs, Sisili and Taburu, recorded 2.40 (±0.68) and 2.60 (±1.29) respectively while Tulagi Island 1.80 (±0.20) (Fig. 19). Ten species of commercial sea cucumbers comprising 57 individuals were recorded in the deep habitat. These were *Holothuria fuscogilva* (White teatfish), *H. edulis* (Pinkfish), *H. nobilis* (Black teatfish), *H. fuscopunctata* (Elephant's trunkfish), *H. atra* (Lollyfish), *Pearsonothuria graeffei* (Orangefish), *Bohadschia argus* (Tigerfish), *Bohadschia vitiensis* (Brown sandfish), *Stichopus hermanni* (Curryfish) and *Thelenota anax* (Amberfish).

Sisili recorded the highest mean number of all commercially important invertebrates with 8.60 (±3.64) (Fig. 20). Rodrigue bay recorded second highest with 3.60 (±1.03), Taburu 2.60 (±1.29), Tulagi Island 1.80 (±0.20) and Darwin 0.80 (±0.80) (Fig. 20). The high mean number recorded for Sisili was attributed to the high counts of the species *Pteria penguin* (brown lip pearl oyster) made at that site.

The most abundant sea cucumber species in the deep habitat at the sites sampled were Pinkfish and white teatfish (Figs. 21 and 22). Pinkfish was present at mean numbers ranging from zero at Darwin to 2.60 (±0.51) at Sisili MPA (Fig. 21). Rodrigue bay recorded the second highest with 1.60 (±0.81), Taburu MPA 1.40 (±0.98) and Tulagi Island 0.80 (±0.37). On the other hand, white teatfish was recorded with mean numbers ranging from zero at Sisili MPA to 0.80 (±0.80) at Darwin (Fig. 22). Rodrigue bay recorded a mean number of 0.60 (±0.60) while Tulagi Island and Taburu recorded 0.40 (±0.24) and 0.20 (±0.20) respectively (Fig. 22). Tigerfish and orangefish were only encountered at the Taburu, Rodrigue bay and Tulagi Island sites (Figs. 23 and 24). Tigerfish was present with the highest mean number at Rodrigue bay with 0.40 (±0.24) and at Taburu and Tulagi Island with 0.20 (±0.20) respectively (Fig. 23). Orangefish was present at the three sites with a mean number of 0.20 (±0.20) (Fig. 24). Amberfish was only seen at Tulagi Island with a mean number of 0.20 (±0.20) (Fig. 25), curryfish, black teatfish, elephant's trunkfish and brown sandfish only at Rodrigue bay with 0.40 (±0.24), 0.20 (±0.20), 0.20 (±0.20) and 0.20 (±0.20) respectively (Figs. 26, 27, 28 & 29) while lollyfish was recorded only at Taburu MPA with a mean number of 0.40 (±0.24) (Fig. 30).

The brown lip pearl oyster was encountered only within the Sisili MPA with a mean number of 6.00 (±3.73).

5.3.1 *Size Frequency Distribution*

Comparison of size frequency distribution among the two MPA sites and the Reference sites is also limited by the relatively small sample sizes. Like in the shallow, 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). The average and size range of the sea cucumber species recorded in the deep are given in Table 5.

6.0 DISCUSSION

The invertebrates listed in Table 2 are those known to be utilized as food resources (e.g. giant clams and beche-de-mer) or have other commercial value (e.g. trochus and pearl oysters) or have traditional, cultural and custom values (*Beguina semiorbiculata* and *Atrina vexillum*) and indicators of coral reef health (e.g. trumpet triton and crown of thorn starfish).

Coastal dwellers of Solomon Islands have always depended on marine resources for their livelihood. With a high dependency on marine resources coupled 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 valued at SBD270.00 per kg in Honiara, (Ramofafia, 2004)), this high dependency is expected to increase further. At the same time, new development in fishing gear technology and methods (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 appropriate management intervention, uncontrolled and unsustainable exploitation of marine resources is inevitable and this may ultimately lead to over-exploitation of the very resources that coastal communities depend on for their livelihood.

Through interviews with members of Leitongo community, many of them recognize that over-harvesting of marine resources is a growing concern in their area. Many of them have also observed that, there has been a reduction in the abundance of many of their marine resources. The result of this baseline study has confirmed this observation, particularly for commercial invertebrates. For example, in the shallow habitat, mean numbers of important invertebrate species in the two MPAs (Sisili and Taburu) and the three reference areas (Rodrigue bay, Tulagi Island and Darwin reef) ranged from 1.33 to 3.83 per transect whereas in the deep habitat, mean numbers of species ranged from 0.20 to 2.20.

While Holland (1994) reported 22 and Ramofafia (2004) a possible 32 species of sea cucumbers being harvested in Solomon Islands respectively, only 11 of these species were recorded in the sampled transects during this baseline study. Many species such as the *Actinopyga mauritiana* (surf redfish), *Holothuria scabra* (sandfish), *Bohadschia similes* (chalkfish), *Thelenota ananas* (prickly redfish), *Actinopyga lecanora* (stonefish), *Stichopus horrens* (peanutfish), *H. nobilis* (blackfish), *S. chloronotus* (greenfish), *Actinopyga echinites* (deepwater redfish) and *H. coluber* (snakefish) were not encountered during the survey. Of the 11 species recorded in sampled transects, 7 occurred only in the deep habitat, 1 only in shallow and 3 in both shallow and deep habitats. The four species found in the shallow habitat comprised 15 individuals. In contrast, the ten species recorded in the deep habitat comprised 57 individuals.

Mean densities of individual sea cucumber species in both the shallow and deep habitats is low. Of the ten high valued species reported for the Solomon Islands (Ramofafia, 2004), only *H. fuscogilva* (white teatfish), *S. hermanni* (curryfish) and *H. nobilis* (black teatfish) were recorded in sampled transects in the deep habitat (these species were not encountered in the shallow habitat). White teatfish was recorded with mean densities of 0 and 8 per hectare for the Sisili and Taburu MPAs respectively compared to 16, 24 and 32 per hectare for the reference areas of Tulagi Island, Rodrigue bay and Darwin reef. In contrast, curryfish and black teatfish were not recorded in the two MPAs but were only recorded at the Rodrigue bay reference area with mean densities of 16 and 8 per hectare respectively. Preston (1993) reported mean densities up to 18 per hectare for white teatfish in Tonga while Lincoln-Smith and Bell (1996) report 16 for the AMCA. Preston (1993) also reported a mean density of 456 per hectare for curryfish in Papua New Guinea, 16.3 and 18.7 for black teatfish in the Great Barrier Reef and Tonga while Lincoln-Smith and Bell (1996) reported 8.4 and 2 per hectare for the same two species respectively.

Although higher mean densities (in the deep habitat) were recorded for white teatfish at the Rodrigue bay and Darwin reef reference areas compared to what is reported elsewhere in the Solomon Islands and other part of the South Pacific region, these density figures may not be accurate considering the fact that only five transects were sampled per study site and the presence of one specimen in these five transects will be equivalent to a mean density of 8 per hectare. These results should be taken with caution especially if one is to use them for comparison with results of work done elsewhere. The main intention for these mean densities however, would be for comparison with results from future assessment surveys undertaken in the two MPAs and three reference areas.

Of the sixteen low valued species reported for the Solomon Islands (Ramofafia, 2004), only the H. *edulis* (pinkfish), *B. argus* (tigerfish), *T. anax* (amberfish), *H. atra* (lollyfish), *Pearsonothuria graeffei* (orangefish), *B. vitiensis* (brown sandfish) and *H. fuscopunctata* (elephant's trunkfish) were found in transects sampled in the shallow and deep habitats. Pinkfish was the most abundant species in the two habitats surveyed. In the shallow habitat for example, both Sisili and Taburu MPAs recorded mean densities of 17 per hectare for the species whereas the reference areas recorded mean densities of 0 at Darwin reef, 17 Rodrigue bay and 83 Tulagi Island. Other species like tigerfish and orangefish were not recorded in the two MPAs but were only seen at Tulagi Island and Rodrigue bay with mean densities of 17 and 83 per hectare respectively. On the other hand, in the deep habitat, the two MPAs recorded mean densities of 104 per hectare at the Sisili MPA and 56 at Taburu for pinkfish. The reference areas recorded 0 per hectare at Darwin, 64 at Rodrigue bay and 32 at Tulagi Island. Tigerfish and orangefish were recorded only at Taburu MPA, Rodrigue bay and Tulagi Island. Tigerfish was recorded with 8 per hectare for at the Taburu MPA while Rodrigue bay and Tulagi Island 16 and 8 respectively. In contrast, orangefish was recorded with a mean density of 8 per hectare for the three sites. Amberfish was present only at Tulagi Island with a mean density of 8 per hectare. Elephant's trunkfish and brown sandfish were recorded only at Rodrigue bay with a mean density of 8 per hectare. Lollyfish was recorded only at the Taburu MPA with a mean of 16 per hectare.

Again as discussed earlier, these results should be treated with caution especially if one is to compare them with studies done elsewhere. However, these mean densities would be useful for comparison with future results for the five sites.

An important observation from the results for sea cucumber species also is that, none was recorded at all five sites sampled either in the shallow or deep habitats. Many of the species found (8 of the 11) were encountered at only one site. Whether the low number of species and densities of sea cucumbers found in both habitats discussed above is due to heavy exploitation or not is not clear, considering the fact that no historical harvest data for these species is available for the sites surveyed.

Not all six species of giant clams known from the Solomon Islands were recorded during this survey. *Tridacna crocea* was the most common species of giant clam recorded among all five study sites with densities ranging from 0 per hectare at Tulagi island to 433 at Rodrigue Bay. The Sisili and Taburu MPAs recorded 300 and 217 per hectare respectively. Compared to mean densities reported in other studies, this is low. For example, Munro (1993) reported densities well over 3,000 individuals per hectare in French Polynesia. However, these mean densities are higher compared to what was reported for the AMCA region by Lincoln-Smith and Bell (1996) and Marau, Ramohia (2004) for the species. *T. maxima,* was recorded at low mean densities of 1.83, 1.50 and 0.33 per transect or equivalent to 183, 150 and 33 per hectare for Taburu MPA, Rodrigue Bay and Darwin reef. Again, this is low compared to mean densities reported in other studies for the species. Munro (1993) reported well over 1,000 individuals per hectare in French Polynesia while Creese and Friedman (1995) 1,400 per hectare for the Indispensable Reef and Lincoln-Smith and Bell (1996) up to 194 for the AMCA region. *T. squamosa* and *Hippopus hippopus* were the least abundant species recorded during the survey. These two species were recorded at densities up to 33 per hectare at the sites they were present. Creese and Friedman (1995) reported higher densities of up to 500 per hectare for the Indispensable Reef for *T. squamosa*. *T. gigas* and *T. derasa* were not recorded at all in this study. These two larger species are vulnerable to over-exploitation but whether the results obtained here is related to over-exploitation or not is not clear as there were no historical harvest data available for these species for the area.

The rock oyster ke'e was the most abundant bivalve species sampled during this survey with mean abundance ranging from 0 per hectare at Tulagi island to 967 per hectare at Darwin reef. The species was present at mean densities of 717 and 417 per hectare at the Sisili and Taburu MPA sites. Blacklip pearl oyster (*Pinctada margaritifera*) on the other hand was present only at Rodrigue Bay and Darwin reef with mean densities of 50 and 33 per hectare for the sites respectively. The government regulation banning the commercial harvest of this species may be helping to maintain wild stocks of the species. Whilst gold lip (*P. maxima*) was not encountered during the survey, Brown lip (*Pteria penquin*) was recorded with mean densities of up to 600 per hectare at the Sisili MPA.

In contrast, *Trochus niloticus* was not encountered in sampled transects during the survey but the false trochus *Tectus pyramis* was recorded at three studies Rodrigue Bay, Tulagi Island and Darwin reef with mean densities up to 33 per hectare. Geographically, the Sisili and Taburu MPAs were more sheltered compared to the three reference areas and generally, trochus prefer exposed habitats to the sheltered reefs. However, since these two species are known to occupy the same habitat and space on the reef, this would imply should trochus be present, these would have been harvested heavily. Kurila (*Atrina vexillum*) was encountered only at Taburu MPA and Rodgrigue Bay with mean densities up to 17 per hectare. Greensnail (*Turbo marmoratus*) was not recorded during this study as well but this is expected as this species prefer very specific habitats on the reef.

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.

7.0 CONCLUSION

Overall, this baseline study has established the following:

(1) The abundance of important (commercial & subsistence) invertebrate species in the Leitongo study area (MPAs & Reference Areas) is lower than reported at other parts of Solomon Islands (Indispensable Reef) and the south Pacific region. The establishment of MPAs by resource owners of Leitongo for the conservation and enhancement of marine resources is a step in the right direction.

(2) Sea cucumber species, especially those of high commercial value, Trochus and the two larger species of giant clams *T. gigas* and *T. derasa* are probably heavily exploited resulting in the low abundance of these animals. The fact that *Trochus niloticus*, *T. gigas* and *T. derasa* were never recorded during the survey is a great concern. This may be result of over-exploitation.

(3) Rodrigue bay has more invertebrate resources than any of the other four areas (MPAs and reference areas) studied. This site should be considered for an MPA in future.

(4) For these MPAs to work or be successful, the Leitongo community must have respect for them. Not only that, partner support for this community initiative will also be necessary to ensure community commitment and interest in the long term.

(5) The government ban on the commercial exploitation of the pearl oyster species Black lip (*Pinctada margaritifera*) is helping to main the wild stocks of the species. This ban should be respected by all communities in Solomon Islands.

(6) No coral damage from crown of thorn starfish *Acanthaster planci* is observed in the study area. Although dynamite fishing used to be practiced in the area and coral harvesting for the aqurium

trade and lime production is taking place, coral destruction associated with these activities is minimal.

8.0 RECOMMENDATION

As explained above, MPAs serve many purposes and can be used as a marine resource management tool to provide many benefits to communities. The establishment of the Sisili and Taburu MPAs is a major step towards the management and conservation of marine resources in Sandfly passage. As such, it will be of paramount importance that the people of Leitongo community respect these two MPAs. At the same time, the support from other stakeholders such FSPI, Department of Fisheries and Marine Resources 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 community 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 coordinated 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, although not absolutely necessary, 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 Coral Gardens Project must cover the cost of acquiring a DAN SCUBA diving Insurance (Diving Insurance) for all personnel involved in the MPA monitoring work.

9.0 ACKNOWLEDGEMENT

This baseline survey has been successful as a result of the contributions of many organizations and individuals. The South Pacific Regional Environmental Program (SPREP) funds this study through the Coral Gardens Project, coordinated by FSPI and the Department of Fisheries and Marine Resources.

The Solomon Islands FSPI and SILMMA coordinator Mr. Silverio Wale is commented for his tireless effort in ensuring FSPI program activities are properly coordinated.

The Chiefs, village elders and members of the Leitongo village community (including Sisili and Taburu settlements) are very supportive of this study and without their support the baseline study would not have been possible.

The willingness and enthusiasm shown by the community representatives to learn and take part in training and the actual baseline survey itself (especially data collection in the shallow habitat) is acknowledged. They include Joseph Keba, Harry Pandapanda, Simon Suba and Isaiah Kapini.

The contribution of those who assisted in data collection in the deep habitat is commented. They include Peter Rex Lausu'u of Department of Fisheries, Hugo Tafea (ECANSI), Ferral Lasi (TNC) and Patrick Mesia (Internal Waters Programme).

10. REFERENCE

Alder, J. (1996). Have tropical marine protected areas worked? An initial analysis of their success. *Coastal Management* 24, pp. 97 - 114

Babcock, R. C., Kelly, S., Shears, N. T., Walker, J. W. and Willis, T. J. (1999). Changes in community structure in temperate marine reserves. *Marine Ecology Progress Series, 189*: 125 – 134.

Bohnsack, J. A. (1990). The potential of marine fishery reserves for reef fish management in the U.S southern Atlantic. Miami: NOAA Technical Memorandum NMFS-SEFC-261, 40 pp.

Bohnsack, J. A. (1993). Marine Reserves: They enhance Fisheries, Reduce Conflicts, and Protect Resources. *Oceanus* pp. 63 – 74.

Dugan, J. E. and Davis G. E. (1993). Applications of marine refugia to coastal fisheries management. *Canadian Journal of Fisheries and Marine Sciences* 50, pp. 2029 – 2042.

Holland, A. (1994). The beche-de-mer industry in the Solomon Islands: recent trends and suggestions for management. SPC Beche-de-Mer Information Bulletin 6: 2-8.

Kelly, S., Scott, D., MacDiarmid, A. B. and Babcock, R. C. (2000). Spiny lobster , *Jasus edwardsii*, recovery in New Zealand marine reserves. *Biological Conservation*, 92: 359 – 369.

Lincoln Smith, M. P. and Bell, J. D. (1996). *Testing the use of marine protected areas to restore and manage tropical multispecies invertebrate fisheries at the Arnavon Islands, Solomon Islands: Abundance and size distributions of invertebrates, and the nature of habitats, prior to declaration of the Marine Conservation Area*. Prepared for the Greta Barrier Reef Marine Park Authority, Canberra and the Australian Centre for International Agricultural Research, Sydney.

Lincoln Smith, M. P., Bell, J. D., Ramohia, P. and Pitt, K. A. (2000). *Testing the use of marine protected areas to restore and manage tropical multispecies invertebrate fisheries at the Arnavon Islands, Solomon Islands: TERMINATION REPORT*. Prepared for the Greta Barrier Reef Marine Park Authority, Canberra and the Australian Centre for International Agricultural Research, Sydney.

Munro, J. L. (1993). Giant clams. Pp 431-450 in, A. Wright and L. Hill (eds), *Nearshore Marine Resources of the South Pacific*. Institute of Pacific Studies, Suva, Forum Fisheries Agency, Honiara and International Centre for Ocean Development, Canada.

Nash, W.J. (1993). Trochus, Pp 371-408 in, A. Wright and L. Hill (eds), *Nearshore Marine Resources of the South Pacific*. Institute of Pacific Studies, Suva, Forum Fisheries Agency, Honiara and International Centre for Ocean Development, Canada.

Nash, W. J., Tuara, P., Terekia O., Munro, D., Amos, M., Leqata, J., Mataiti, N., Teopa, M., Whiteford, J., and Adams, T. (1995). *The Aitutaki trochus fishery: a case study*. Inshore Fisheries Research Project Technical Document No. 9, pp72.

Parrish, R. (1999). Marine reserves for fisheries management: Why not. *CalCOFl Report*, Volume 40, 1999: 77 – 86.

Preston, G. L. (1993). Beche-de-Mer. Pp 371-408 in, A. Wright and L. Hill (eds), *Nearshore Marine Resources of the South Pacific*. Institute of Pacific Studies, Suva, Forum Fisheries Agency, Honiara and International Centre for Ocean Development, Canada.

Ramofafia, C. (2004). The Sea Cucumber Fisheries in Solomon Islands: Benefits and Importance to Coastal Communities. WorldFish Centre, Nusa Tupe Field Station, 10pp.

Roberts, C. M and Polunin, N. V. C. (1993). Marine Reserves: simple solutions to managing complex fisheries? *Ambio* 22, pp. 363 – 368.

Sladek Nowlis, J. and Roberts, C. M. (1997). You can have your fish and eat it too: theoretical approaches to marine reserve design. In: *Proceedings of the 8th International Coral Reefs Symposium, Panama*, 1996, 2: 1907 – 1910.

Sladek Nowlis, J. and Roberts, C. M. (1999). Fisheries benefits and optimal design of marine reserves. Fisheries Bulletin, 97: 604 – 616.

Tsutsui, I and Sigrah, R. (1994). Natural broodstock resources in Kosrae, Federated States of Micronesia. *SPC Trochus Information Bulletin, 3: 9-11*.

Wright, A and Hill, L. E. (1993). *Nearshore Marine Resources of the South Pacific*. Institute of Pacific Studies, Suva, 710 pp.

Table 1a: A general description of the sampling sites

SHALLOW AND DEEP HABITATS

Locality	**Site**	**Site Description**
Sisili MPA	S1/D1	Sheltered reef terrace and slope next to Sisili settlement
Taburu MPA	S2/D2	Sheltered reef terrace and sloe next to Taburu settlement
Rodrigue Bay	S3/D3	Protected reef terrace and slope in the Rodrigue bay close to the World Discoverer wreck.
Tulagi Island	S4/D4	Sheltered reef terrace and slope on Tulagi island
Darwin Reef	S5/D5	Reef terrace and slope on western side of the southern entrance of Sandfly passage

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

LOCALITY	**SITE**	**LAT. (South)**	**Long. (East)**
Sisili MPA	S1	08^o 59.94’	160^o06.19’
Taburu MPA	S2	09^o 00.18’	160^o04.89’
Rodrigue Bay	S3	09^o 01.36’	160^o07.60’
Tulagi Island	S4	08^o 02.11’	160^o06.30’
Darwin Reef	S5	09^o 01.88’	160^o04.16’
Sisili MPA	D1	09^o 00.08’	160^o06.10’
Taburu MPA	D2	09^o 00.23’	160^o04.89’
Rodrigue Bay	D3	09^o 01.41’	160^o07.60’
Tulagi Island	D4	09^o 02.11’	160^o06.30’
Darwin Reef	D5	09^o 01.89’	160^o04.17’

Table 2: Invertebrate species studied during 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	*Pearsonothuria graeffei*
Sea cucumbers	Greenfish	*Stichopus chloronotus*
Sea cucumbers	Dragonfish (Peanutfish)	*Stichopus horrens*
Sea cucumbers	Curryfish	*Stichopus hermanni*
Sea cucumbers	Brown curryfish	*Stichopus vastus*
Sea cucumbers	Prickly redfish	*Thelenota ananas*
Sea cucumbers	Amberfish	*Thelenota anax*
Sea cucumbers	Lemonfish	*Thelenota rubralineatus*
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*
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: List of community representatives who were trained in the survey methodologies during this baseline survey

Name	MPA Represented and Village
Joseph Keba	VDW - Ngella communities
Harry Pandapanda	Sisili MPA – Leitongo
Simon Suba	Taburu MPA – Leitongo
Isaiah Kapini	Maravaghi MPA – Maravaghi Resort

Table 4: Invertebrate species composition and distribution for the two habitats surveyed.

SHALLOW HABITAT	DEEP HABITAT	SHALLOW AND DEEP HABITAT
Sea Cucumbers		
Stichopus vastus (brown curryfish)	*Bohadschia vitiensis* (brown sandfish)	*B. argus* (tigerfish)
	Hothuria atra (lollyfish)	*H. edulis* (pinkfish)
	H. fuscogilva (white teatfish)	*Pearsonothuria graeffei* (orangefish)
	H. fuscopunctata (elephant's trunkfish)	
	H. nobilis (black teatfish)	
	Thelenota anax (Amberfish)	
	S. hermanni (curryfish)	
Bivalves		
Tridacna crocea	-	*Pteria penguin (brownlip)*
Tridacna maxima	-	-
Tridacna squamosa	-	-
Hippopus hippopus	-	-
Pinctada margaritifera (blacklip)	-	-
Beguina semiorbiculata (Ke'e)	-	-
Atrina vexillum (Kurila)	-	-
Gastropods		
Tectus pyramis (False trochus)	-	-
Trochus maculatus	-	-

Table 5: Number and average sizes of some invertebrate species recorded during the baseline study.

Shallow Habitat **Species**	**Average size (cm)**	**Numbers found (n)**	**Range (cm)**
Tridacna squamosa	21.2	3	19.0 – 23.0
T. maxima	11.5	21	4.0 – 23.0
T. crocea	6.2	59	2.0 – 13.0
H. hippopus	21.8	2	18.5 – 25.0
Pinctada margaritifera (blacklip)	13.4	5	12.0 – 15.0
Holothuria edulis (pinkfish)	38.2	7	27.5 – 46.0
Pearsonothuria graeffei (orangefish)	33.6	5	25.0 – 43.0
Deep Habitat			
H. fuscogilva (white teatfish)	42.6	10	29.0 – 54.0
Bohadschia argus (tigerfish)	44.3	4	36.0 – 54.0
Pearsonothuria graeffei (orangefish)	34.3	3	33.0 – 40.0
H. edulis (pinkfish)	31.7	31	21.5 – 44.0
Stichopus hermanni (curryfish)	46.5	2	38.0 – 55.0
H. atra (lollyfish)	47.0	2	40.0 – 54.0

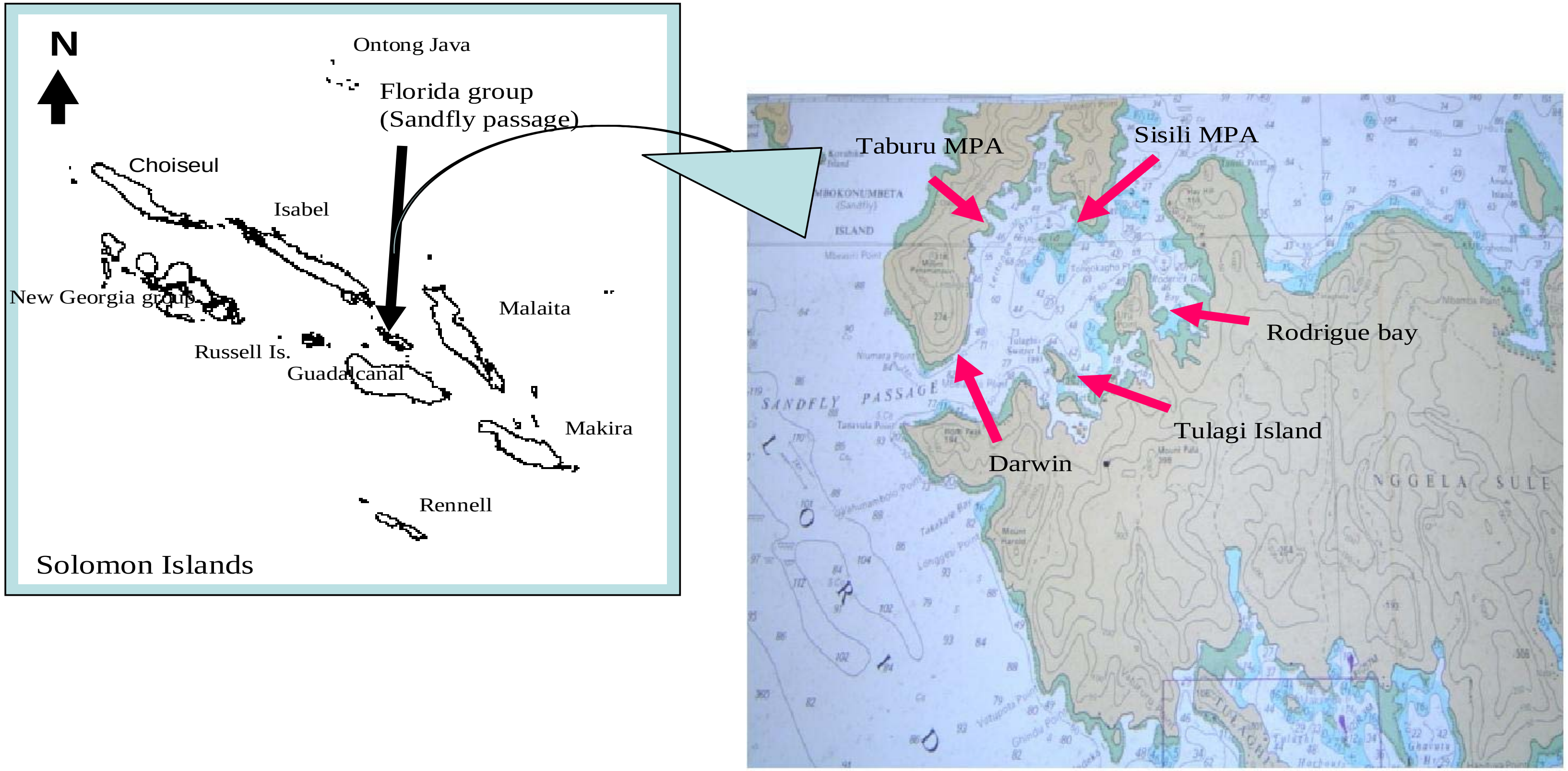

Figure 1: Map of Solomon Islands and Sandfly passage showing the sites sampled

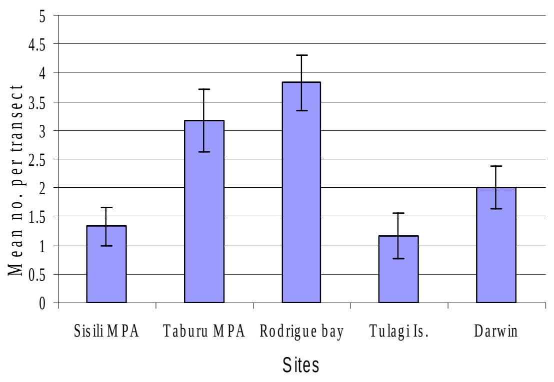

Figure 2: Mean number (±SE, n=6) of species for the sites in each of the two MPAs and the three reference areas in the shallow habitat

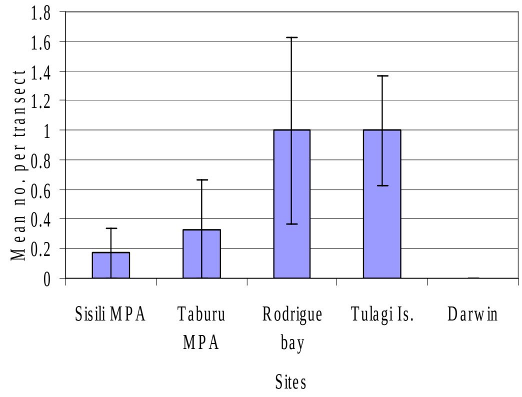

Figure 3: Mean number (±SE, n=6) of all sea cucumbers for the sites in each of the two MPAs and the three reference areas in the shallow habitat

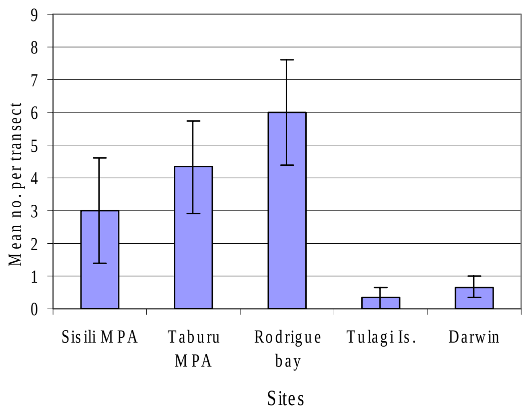

Figure 4: Mean number (±SE, n=6) of all giant clams for the sites in each of the two MPAs and the three reference areas in the shallow habitat

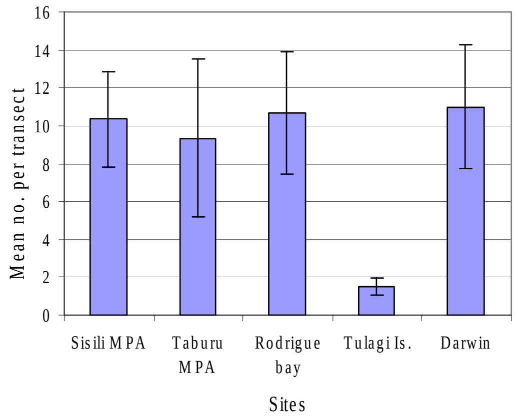

Figure 5: Mean number (±SE, n=6) of all invertebrates for the sites in each of the two MPAs and the three reference areas in the shallow habitat

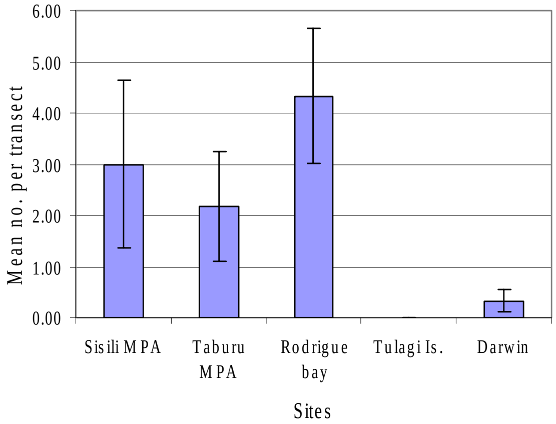

Figure 6: Mean number (±SE, n=6) of *T. crocea* for the site in each of the two MPAs and the three reference areas in the shallow habitat

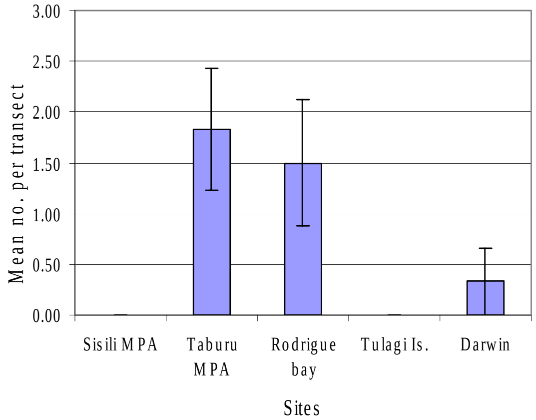

Figure 7: Mean number (±SE, n=6) of *T. maxima* for the site in each of the two MPAs and the three reference areas in the shallow habitat

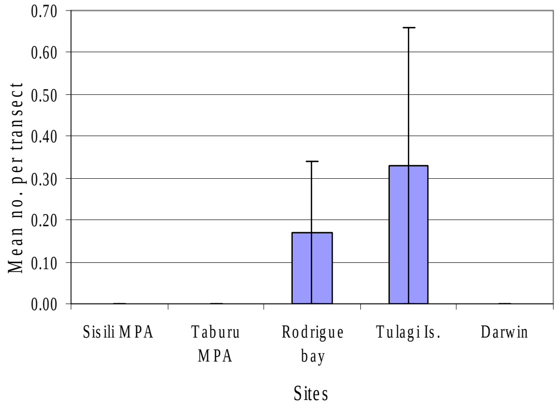

Figure 8: Mean number (±SE, n=6) of *T. squamosa* for the site in each of the two MPAs and the three reference areas in the shallow habitat

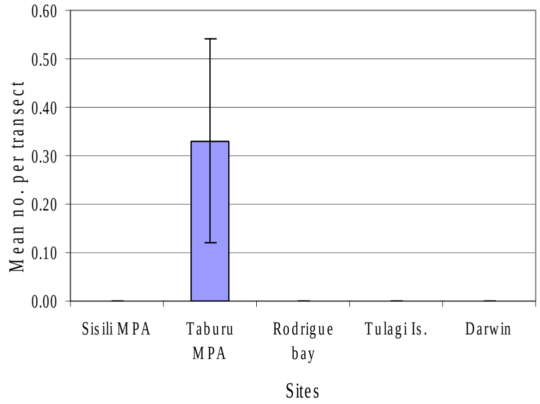

Figure 9: Mean number (±SE, n=6) of *H. hippopus* for the site in each of the two MPAs and the three reference areas in the shallow habitat

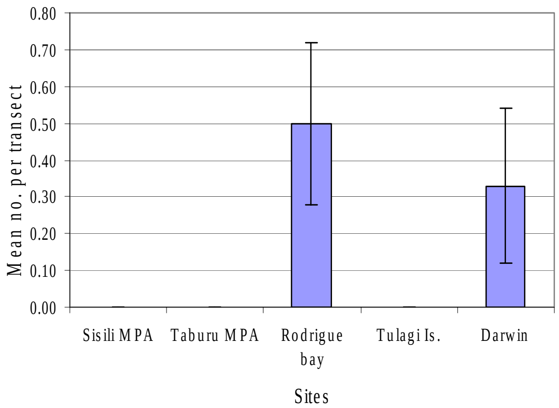

Figure 10: Mean number (±SE, n=6) of *P. margaritifera* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

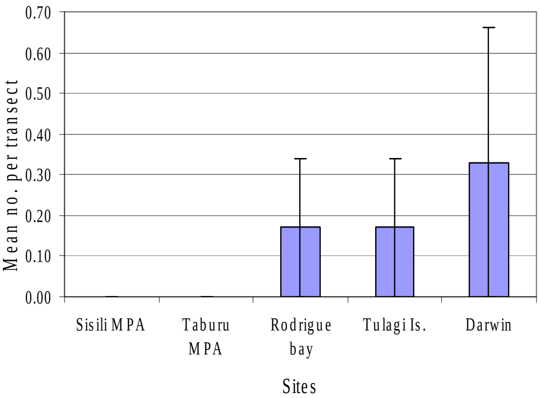

Figure 11: Mean number (±SE, n=6) of *T. pyramis* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

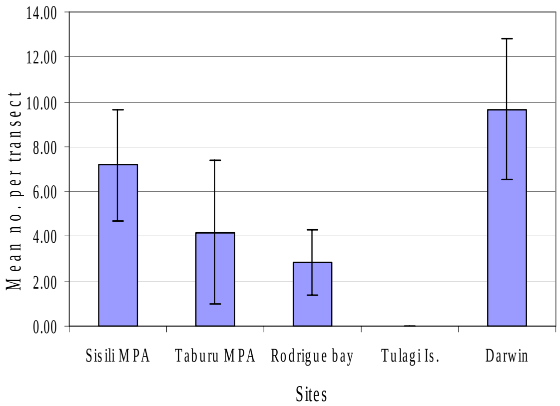

Figure 12: Mean number (±SE, n=6) of *B. semiorbiculata* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

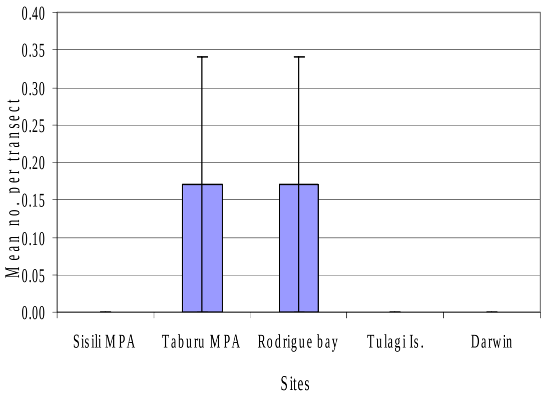

Figure 13: Mean number (±SE, n=6) of *A. vexillum* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

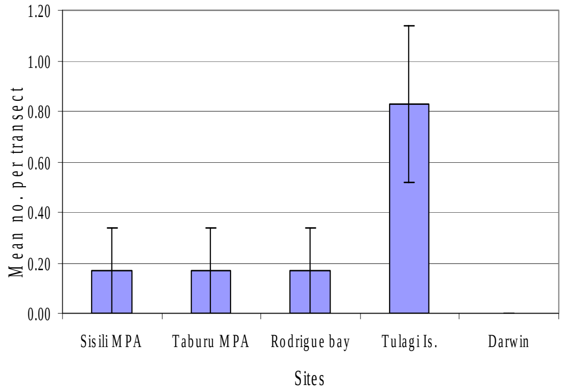

Figure 14: Mean number (±SE, n=6) of *H. edulis* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

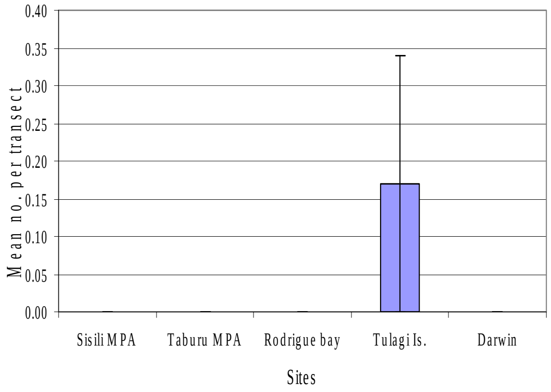

Figure 15: Mean number (±SE, n=6) of *B. argus* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

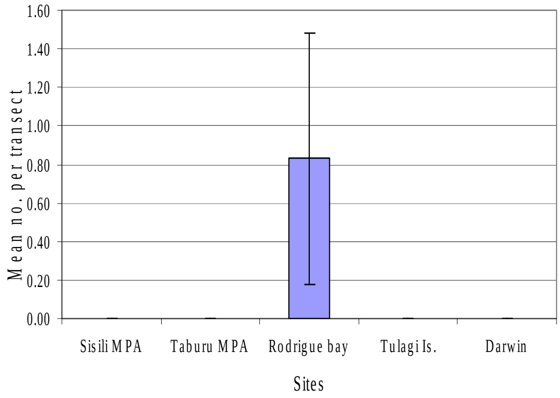

Figure 16: Mean number (±SE, n=6) of *P. graeffei* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

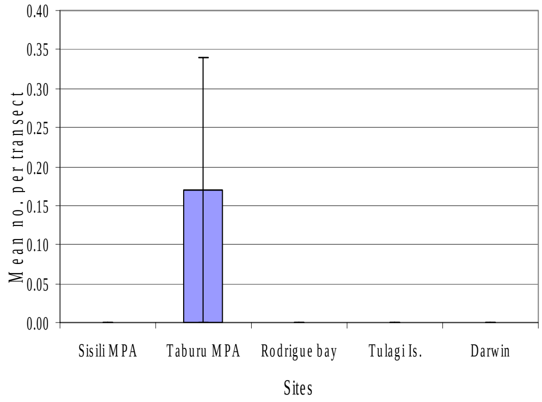

Figure 17: Mean number (±SE, n=6) of *S. vastus* for the sites in each of the two MPAs and the three reference areas in the shallow habitat

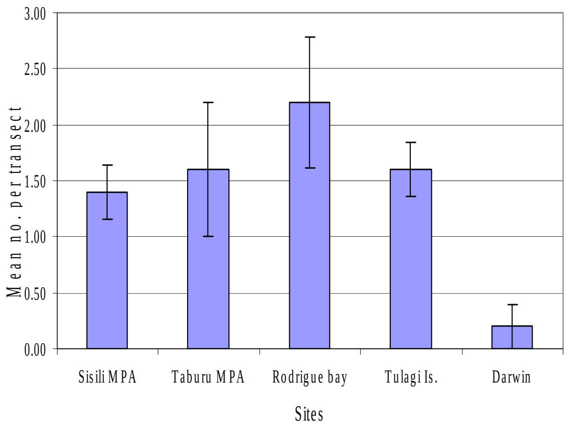

Figure 18: Mean number (±SE, n=5) of all species for the sites in the two MPAs and the three reference areas in the deep habitat

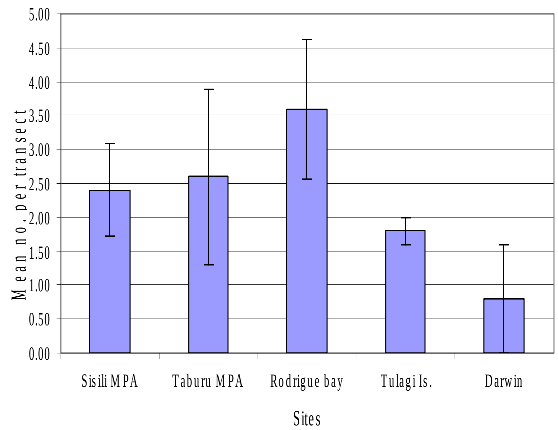

Figure 19: Mean number (±SE, n=5) of all sea cucumbers for the sites in the two MPAs and the three reference areas in the deep habitat

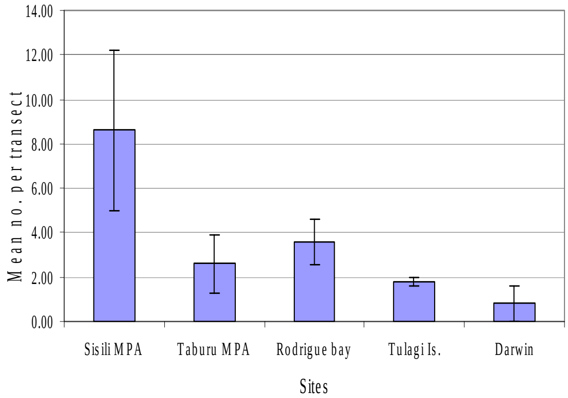

Figure 20: Mean number (±SE, n=5) of all invertebrates for the sites in the two MPAs and the three reference areas in the deep habitat

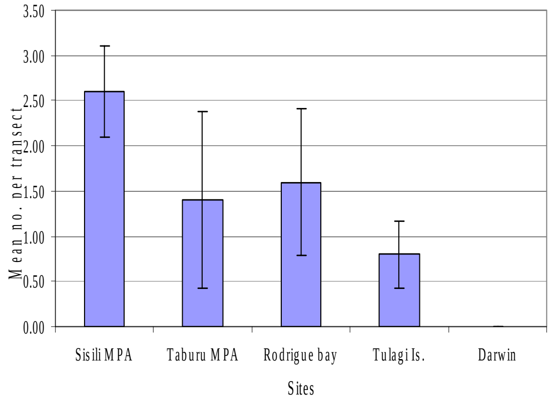

Figure 21: Mean number (±SE, n=5) of *H. edulis* for the sites in the two MPAs and the three reference areas in the deep habitat

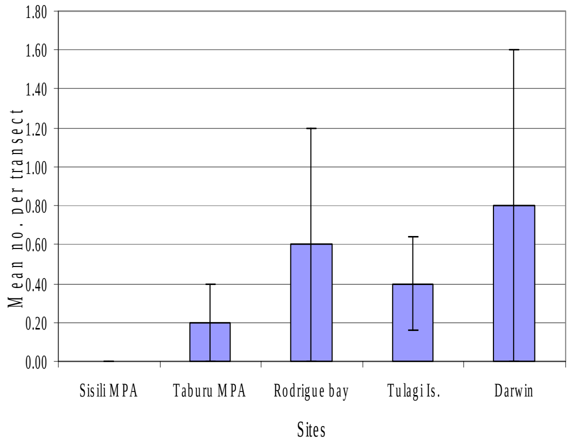

Figure 22: Mean number (S±E, n=5) of *H. fuscogilva* for the sites in the two MPAs and the three reference areas in the deep habitat

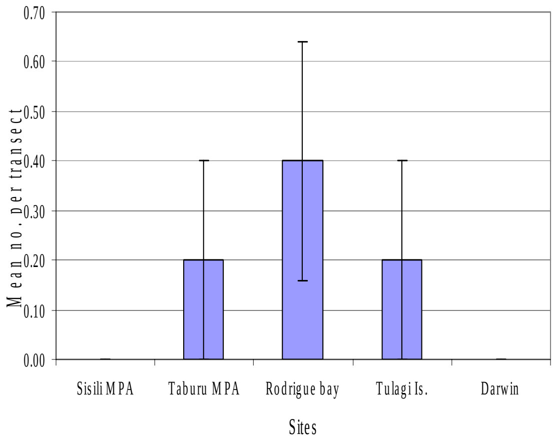

Figure 23: Mean number (±SE, n=5) of *B. argus* for the sites in the two MPAs and the three reference areas in the deep habitat

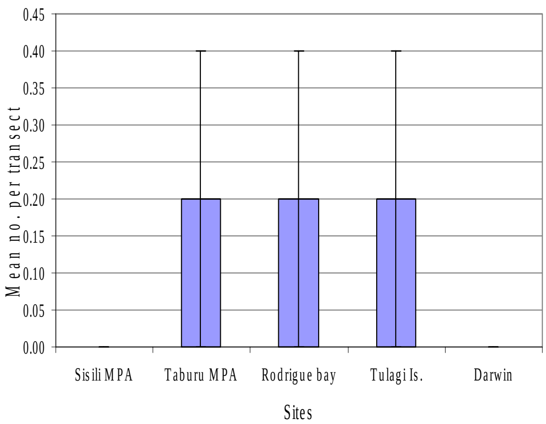

Figure 24: Mean number (±SE, n=5) of *P. graeffei* for the sites in the two MPAs and the three reference areas in the deep habitat

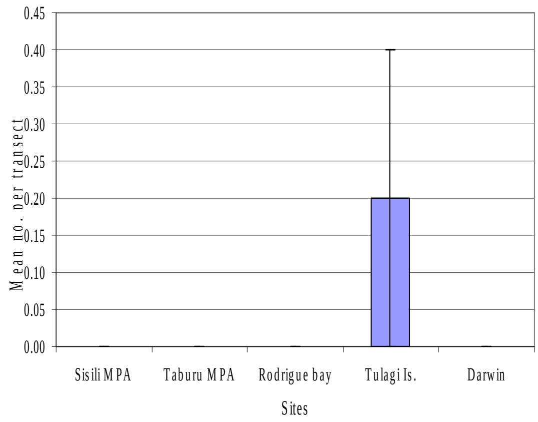

Figure 25: Mean number (±SE, n=5) of *T. anax* for the sites in the two MPAs and the three reference areas in the deep habitat

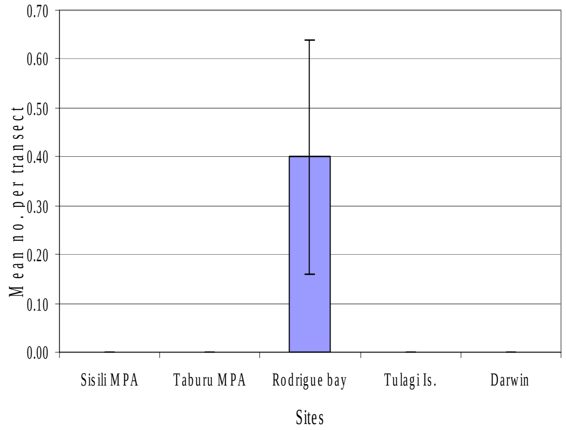

Figure 26: Mean number (±SE, n=5) of *S. hermanni* for the sites in the two MPAs and the three reference areas in the deep habitat

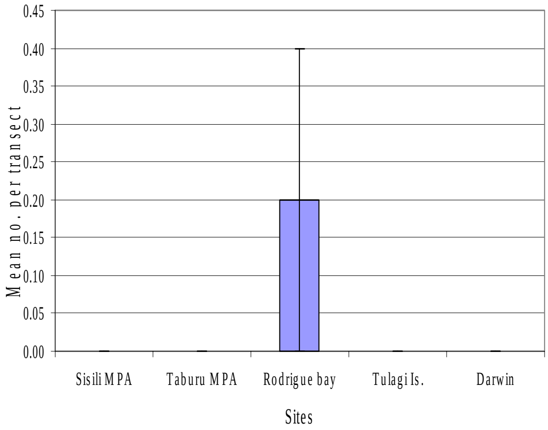

Figure 27: Mean number (±SE, n=5) of *H. nobilis* for the sites in the two MPAs and the three reference areas in the deep habitat

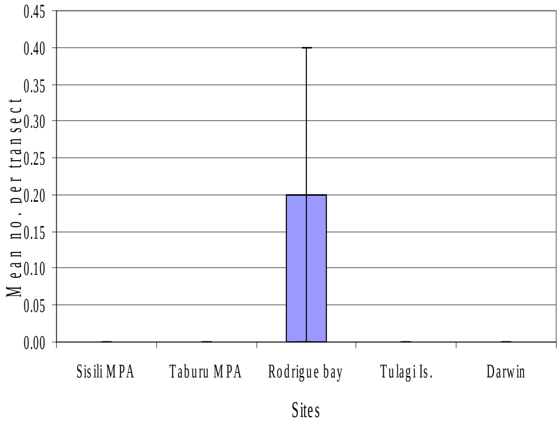

Figure 28: Mean number (±SE, n=5) of *H. fuscopunctata* for the sites in the two MPAs and the three reference areas in the deep habitat

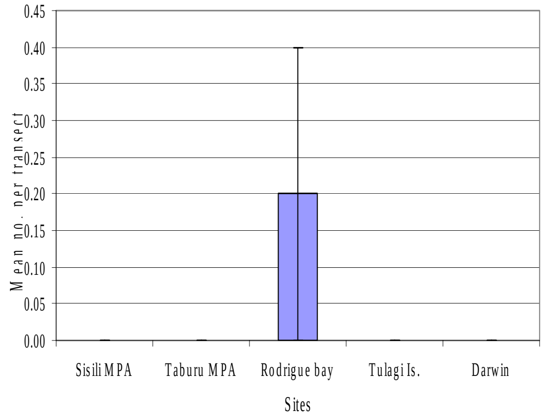

Figure 29: Mean number (±SE, n=5) of *B. vitiensis* for the sites in the two MPAs and the three reference areas in the deep habitat

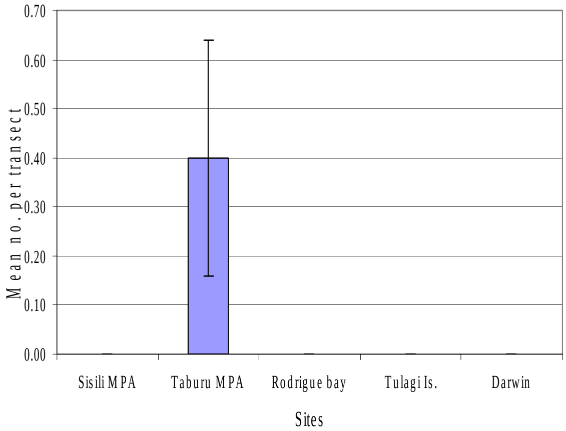

Figure 30: Mean number (±SE, n=5) of *H. atra* for the sites in the two MPAs and the three reference areas in the deep habitat

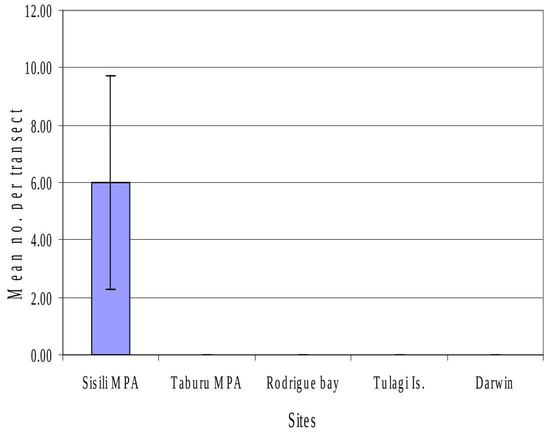

Figure 31: Mean number (±SE, n=5) of *P. penguin* for the sites in the two MPAs and the three reference areas in the deep habitat