PACIFIC REGIONAL OCEANIC AND

COASTAL FISHERIES DEVELOPMENT PROGRAMME

(PROCFish/C/CoFish)

SOLOMON ISLANDS COUNTRY REPORT:

PROFILES AND RESULTS FROM SURVEY WORK AT NGGELA, MARAU, RARUMANA AND CHUBIKOPI

(June to September 2006 and December 2006)

by

Silvia Pinca, Aliti Vunisea, Ferral Lasi, Kim Friedman, Mecki Kronen, Ribanataake Awira, Pierre Boblin, Emmanuel Tardy, Lindsay Chapman, and Franck Magron

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PROCFish/C and CoFish staff work (or used to work) for the Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia under this EU-funded project. All PROCFish/C and CoFish staff work as a team, so even those not directly involved in fieldwork usually assist in data analysis, report writing, or reviewing drafts of site and country reports.
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[1] CoFish and PROCFish/C are part of the same programme, with CoFish covering the countries of Niue, Nauru, Federated States of Micronesia, Palau, Marshall Islands and Cook Islands (ACP countries covered under EDF 9 funding) and PROCFish/C countries covered under EDF 8 funding (the ACP countries: Fiji, Tonga, Papua New Guinea, Solomon Islands, Vanuatu, Samoa, Tuvalu and Kiribati, and French overseas countries and territories (OCTs): New Caledonia, French Polynesia, and Wallis and Futuna). Therefore, CoFish and PROCFish/C are used synonymously in all country reports.

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

The coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) conducted fieldwork in four locations around Solomon Islands from July to September, and in December 2006. Solomon Islands is one of 17 Pacific Island countries and territories being surveyed over a 5–6 year period by PROCFish or its associated programme CoFish (Pacific Regional Coastal Fisheries Development Programme)[2].

The aim of the survey work was to provide baseline information on the status of reef fisheries, and to help fill the massive information gap that hinders the effective management of reef fisheries.

Other programme outputs include:

- implementation of the first comprehensive multi-country comparative assessment of reef fisheries (finfish, invertebrates and socioeconomics) ever undertaken in the Pacific Islands region using identical methodologies at each site;
- dissemination of country reports that comprise a set of 'reef fisheries profiles' for the sites in each country in order to provide information for coastal fisheries development and management planning;
- development of a set of indicators (or reference points to fishery status) to provide guidance when developing local and national reef fishery management plans and monitoring programmes; and
- development of data and information management systems, including regional and national databases.

Survey work in Solomon Islands covered three disciplines (finfish, invertebrate and socioeconomic) in each site, with two sites surveyed on each trip by a team of five programme scientists and several local attachments from the Solomon Islands Fisheries Department, and The Nature Conservancy. The fieldwork included capacity building for the local counterparts through instruction on survey methodologies in all three disciplines, including the collection of data and inputting the data into the programme's database.

In Solomon Islands, the four sites selected for the survey were Nggela, Marau, Rarumana and Chubikopi. These sites were selected based on specific criteria, which included:

- having active reef fisheries,
- being representative of the country,
- being relatively closed systems (people from the site fish in well-defined fishing grounds),
- being appropriate in size,
- possessing diverse habitat,
- presenting no major logistical problems,
- having been previously investigated, and
- presenting particular interest for the Solomon Islands Fisheries Department.

[2] CoFish and PROCFish/C are part of the same programme, with CoFish covering the countries of Niue, Nauru, Federated States of Micronesia, Palau, Marshall Islands and Cook Islands (ACP countries covered under EDF 9 funding) and PROCFish/C countries covered under EDF 8 funding (the ACP countries: Fiji, Tonga, Papua New Guinea, Solomon Islands, Vanuatu, Samoa, Tuvalu and Kiribati, and French overseas countries and territories (OCTs): New Caledonia, French Polynesia, and Wallis and Futuna). Therefore, CoFish and PROCFish/C are used synonymously in all country reports.

Results of fieldwork at Nggela

Sandfly Island is located in Central Province on the western end of the main island of Nggela being separated by the narrow Sandfly passage. Our survey work was focused on the western part of Sandfly, which includes Olevugha, Semege, Niumala, Mangalonga, Ravusodukosi and surrounding islets. The island/islets surveyed tend to have a crenulated coastline, a legacy of its geological past. There is an absence of large mangrove forest except for small isolated patches surrounding semi-enclosed bays. There is strong water exchange through the islands, resulting in high oceanic influence and permanent presence of clear waters. Reef flats in Sandfly tend to be narrow in width. Large outbreaks of crown-of-thorns starfish were seen on some reefs. Fishers reported that infestation has been ongoing for some time. A significant area on the affected reefs has been bleached or degraded.

The Nggela community's proximity to Honiara and the existing transport opportunities, although not easy, have made Nggela one of the most regular suppliers of seafood to the Honiara market. The lack of electricity limits the preservation and processing of agricultural and fishery produce. Fisheries produce is sold to middlemen and agents and, to a much lesser extent, sold directly to clients at the Honiara market.

Socioeconomics: Nggela

Nggela's population is highly dependent upon their marine resources for income and home consumption. Fresh fish consumption is high (98.6 kg/person/year) and represents the most important food and protein source. However, agriculture is even more important as income than fisheries, and also contributes substantially to the food supply of local families. Only females exclusively fish for invertebrates and only males exclusively fish for finfish. Most fishers, males and females, fish for both finfish and invertebrates.

Finfish is mainly sourced from the sheltered coastal reef and lagoon, mostly using non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers fishing commercially, and mostly using motorised boat transport. Deep-bottom and pelagic fisheries also provide substantial revenues. Catches of giant clams (in particular *Tridacna crocea* and *T. maxima*), *Holothuria* spp., *Pinna bicolor*, trochus, *Strombus* spp., sea urchins, and lobsters account for most of the annual harvest (wet weight) of invertebrates. These species represent a mix of species used for commercial and subsistence needs.

Finfish resources: Nggela

The reef habitat in Nggela was relatively rich. The finfish resources in the outer reef – the only survey habitat present – were found to be healthier than in the other three outer reefs surveyed in the country. Fish density, size ratio and biomass were all much higher than at the other sites. The trophic structure was dominated by herbivores, especially Acanthuridae, but this could be related to the high percentage cover of hard bottom. Average size ratio per family also indicated good resource status, since almost all families recorded sizes larger than 55% of their maximum size. Nggela populations of Lethrinidae, Lutjanidae and Mullidae were important in biomass and at a similar level to the populations in Marau.

Invertebrate resources: Nggela

Shallow-water reef suitable for giant clams was not extensive at Nggela, and the habitat was not complex enough to support the full range of giant clams found in Solomon Islands. *Hippopus hippopus* clams were not common, mainly due to the type of environment present, but *Tridacna squamosa* and *T. derasa* were critically depleted and *T. gigas* was 'commercially extinct'[3]. Although *T. maxima*, *T. crocea* and *T. squamosa* displayed a relatively 'full' range of size classes, the low abundance of clams and scarcity of large sizes suggest that clams are heavily impacted by fishing.

Local reefs at Nggela provide a relatively extensive and good habitat for adult trochus (*Trochus niloticus*, the commercial topshell), although suitable habitat for juvenile trochus was less extensive. No high-density aggregations of trochus were identified. Large-sized trochus, important for egg production, were found to be depleted, which means that it may take 5 or more years for stocks to recover to a state where they are again productive. The low commercial value green topshell, *Tectus pyramis*, and blacklip pearl oyster, *Pinctada margaritifera*, were relatively common at Nggela. The green snail (*Turbo marmoratus*), a native species commonly found in Nggela during previous surveys, was not noted in this survey and is considered commercially extinct.

Sea cucumbers were well spread across the site, although medium- and high-value commercial species, such as the leopard or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*), were not common. Unusually, low-value species, such as lollyfish (*H. atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*) were also at relatively low density. The low density of most sea cucumber species suggests that there is little potential for further harvesting at this time. The oceanic nature of the area and its dynamic water movement suited the high-value, deeper-water white teatfish (*H. fuscogilva*).

Recommendations for Nggela

- Community fisheries management projects need to be continued and improved, with a precautionary approach to resource use. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures for specific invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Nggela fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- Pressure on finfish resources is already extremely high and high also on at least a number of invertebrate species. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

[3] Commercially extinct means in this context that the clams were at such a low density as to make them unavailable for any trade and in danger of complete local extinction.

- Cooperation among governmental, NGO and other external institutions, and the Nggela community needs to be fostered in order to ensure the success of improved fisheries management.

- For successful stock management, giant clams need to be maintained at higher density and include larger-sized individuals, to ensure there is sufficient spawning taking place to produce new generations.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha.

- Management arrangements need to be developed and implemented for sea cucumbers given the low densities of most species.

Results of fieldwork at Marau

Marau Sound, Guadalcanal Province, is a large lagoon at the eastern tip of Guadalcanal with fringing reefs around clusters of islands. Marau Sound and part of the north-west coast are the only areas with sea-level reef flats on Guadalcanal. Marau itself is enclosed by a crescent-shaped, partially drowned reef. In Marau, the islands which are located close to the mainland are surrounded by thick mangrove forests with intermittent patches of narrow reef flats (<20 m wide) at their fringes. Islands further out facing the open ocean tend to have wider reef flats, reaching 0.5 km in some areas. There is a high rate of water exchange through the inlets, resulting in permanent clear waters inside the Sound. There is high coral diversity and healthy coral growth; however, live-coral cover was low-to-moderate. Moderate-to-high crown-of-thorns starfish infestation was observed in a number of reefs in Marau.

The Marau community is an isolated, rural coastal community that is scattered over small islands and part of the mainland in the Guadalcanal district. Its isolation is increased by the difficult and expensive transportation links to major centres. This isolation, the lack of transport and marketing infrastructure, lack of access to electricity, ice or other preservation facilities, as well as the loss of a market centre in Marau, have resulted in people living a self-sustained, low-income lifestyle, with few opportunities for change, salaries or purchasing power for imported food items. Middlemen and agents visit Marau fortnightly to purchase finfish and invertebrates, with trochus shell sold on a monthly basis.

Socioeconomics: Marau

Marau's population is highly dependent on marine resources for income and home consumption. Fresh-fish consumption (101 kg/person/year) is high and represents the most important food and protein source. Tradition does not demand particular gender roles, although females are banned from certain fishing activities and areas. Females are the only exclusive invertebrate fishers, while males are the only exclusive finfish fishers. However, most male and female fishers fish for both finfish and invertebrates.

Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers and is intended for commercial purposes. Catches of giant clams, in particular *Tridacna maxima*, the crab *Scylla serrata*, trochus *Sipunduculus* spp., *Holothuria* spp., *Tectus* spp. and *Strombus* spp., account for most of the annual harvest (wet weight) of invertebrates. These species are used for commercial and subsistence needs.

Finfish resources: Marau

The reef habitat in Marau was found to be relatively rich and able to support fairly diverse finfish resources. Finfish resources in Marau were found to be richer than in the other PROCFish/C sites surveyed, with the highest values of fish density, average sizes and biomass. The trophic composition displayed a good representation of carnivores, more important than herbivores in terms of biomass. Although groupers (Serranidae) were rare, snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) were present in large numbers in all reef habitats. Preliminary results suggest that this trend could be due to less-than-average impact from fishing, especially on carnivorous species. Herbivores were dominated by Acanthuridae, while Scaridae were relatively low in abundance. Even the average sizes of fish in the different habitats appeared to be large, a further indication that resources here are healthy. The healthiest habitat was found to be the back-reefs. The intermediate reefs showed the first signs of decrease in resources, with smaller fish sizes and lower density.

Invertebrate resources: Marau

The sheltered lagoon reef at Marau, with its complex structure and dynamic water movement, was very suitable for giant clams. Giant clam presence was moderate, but density was in general low considering the suitability of the environment. Although *T. maxima*, *T. crocea* and *T. squamosa* displayed a relatively 'full' range of size classes, the abundance of clams close to shore, and of large clams, was relatively low. This information, in addition to the low abundance and density, suggest that giant clams in Marau are heavily impacted by fishing.

Local reef conditions at Marau provide an extensive and good habitat for juvenile and adult trochus (*Trochus niloticus*). Trochus were widely distributed at easily accessible reefs, although no aggregations were identified outside the barrier reef. The current population has very few large, old shells (>11 cm basal width). The low commercial value green topshell (*Tectus pyramis*) and blacklip pearl oyster (*Pinctada margaritifera*) were relatively common at Marau. The green snail (*Turbo marmoratus*), a native species commonly found in Marau on past surveys, was not recorded in this survey and is considered to be commercially extinct in Marau.

Sea cucumbers were well spread across the site, although medium- and high-value commercial species, such as the leopard or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*), were not common. Unusually, low-value species, such as lollyfish (*H. atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*), were also not common. The oceanic nature of the area suited the high-value, deeper-water white teatfish (*H. fuscogilva*), which was moderately common. With careful management of harvests, a small regular harvest of this species is possible in Marau. However, overall, the low density of most sea cucumber species and species groups suggests that the fishery has little potential for further harvesting at this time.

Recommendations for Marau

- Community fisheries management projects need to be continued and improved, with a precautionary approach to resource use. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Marau fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- Pressure on some finfish resources is already high, and high also on at least a number of invertebrate species. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

- Intermediate reefs were the poorest of the four habitats present and increase in finfish fishing should be avoided in this reef. However, further development of reef fish fisheries, especially in back-reefs and coastal reefs, could be sustainable if accompanied by appropriate management and regular monitoring to follow the response of resources.

- Cooperation among governmental, NGO and other external institutions, and the community needs to be sought in order to ensure the success of improved fisheries management.

- For successful stock management, giant clams need to be maintained at higher density and include larger-sized individuals, to ensure there is sufficient spawning taking place to produce new generations.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha.

- Management arrangements need to be developed and implemented for sea cucumbers given the low densities of most species.

Results of fieldwork at Rarumana

The Rarumana community consists of a number of villages, which are scattered along the coastal fringe of the northern part of Parara Island, Western Province. The population of the community is estimated to be more than 1000 in 2006. Most members of the community belong to the United Church. Our survey work was conducted on islets and reefs inside the lagoon surrounding the community. There is strong water exchange between the ocean and the lagoon, resulting in moderately clear lagoonal waters. Consequently, there is an absence of mangrove forest on the site surveyed except for areas on the borders and bays that are outside of the study areas. Reef flats in Rarumana tend to be narrow in width. Exceptions are the outer reefs, which are much wider (100–300 m). There was good coral cover and growth especially in the mid and outer part of the lagoon.

The Rarumana community is a rural coastal island community with little access to market opportunities for selling their fishery produce. Market access is limited by the oversaturated market at Gizo, little local market capacity, and high transport costs to the Honiara market. Lack of electricity and thus easy access to ice making also makes it difficult to transport fresh fishery produce, or to process fishery produce on a large scale. The community's lifestyle is determined by agricultural production, also the most important means of generating cash income. The purchasing power of the people for imported food and other items is low. In addition to fisheries, local business activities, including food preparation and food, lime and betel nut sales, provide other income opportunities.

Socioeconomics: Rarumana

Rarumana's population is highly dependent on marine resources for home consumption and, to a lesser extent, for income generation. Fresh-fish consumption (~111 kg/person/year) is high and represents the most important food and protein source. Tradition does not demand particular gender roles; however, females are the only exclusive invertebrate fishers, while exclusive finfish fishers are mostly males. Most fishers, male and females, fish for both finfish and invertebrates

Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers and some of this catch is intended for commercial purposes. Handlines and spear diving are the main methods used in almost all the habitats, while deep-bottom lines and trolling are also used at the outer reef. Catches of giant clams, in particular *Hippopus hippopus* and *Tridacna crocea*, but also other Tridacnidae, *Strombus* sp. and *Charonia tritoris*, account for most of the annual harvest (wet weight) of invertebrates. Most invertebrate catch is used for home consumption only.

Finfish resources: Rarumana

The present assessment indicated that the status of finfish resources in Rarumana is low when compared to the average across Solomon Islands study sites. Detailed assessment at reef level also revealed density, size and biomass to be generally lower than at corresponding reef habitats in Marau and higher than in Chubikopi. Only biodiversity was extremely high in the outer reef, where it reached the top value among all habitats and sites. A consistent dominance of herbivore families, especially Acanthuridae and Scaridae, dominating trophic composition in back and outer reefs, was an indication of a high level of use. Carnivores (Lutjanidae and Lethrinidae) were only significantly present in back and outer reefs. Lethrinidae and Mullidae displayed constantly low size ratios, suggesting their response to heavy fishing. Lutjanidae and Serranidae displayed a similar trend of size reduction in intermediate and coastal reef respectively.

Invertebrate resources: Rarumana

The lagoon at Rarumana provided suitable habitat for the full range of giant clams found in Solomon Islands. Giant clam presence and density were moderate considering the nature of the environment. Although *T. maxima* and *T. squamosa* displayed a relatively 'full' range of size classes, larger shell sizes of the boring clam (*T. crocea*) were noticeably impacted. The presence of young clams indicates that successful spawning and recruitment is still occurring, but the low abundance and scarcity of large sizes suggest that giant clams are impacted by fishing.

Local reef conditions at Rarumana constitute an extensive and good habitat for adult and juvenile trochus (*Trochus niloticus*). Trochus were widely distributed at reefs around Rarumana that were easily accessible for fishers. The general outlook for the fishery is poor as density was very low and no high-density spawning aggregations were identified. Size-class information revealed that recruitment was still occurring but was weak. Previous harvests have comprehensively impacted stock density in most areas, and this is negatively impacting the potential for the creation of young trochus. The low commercial value green topshell (*Tectus pyramis*) which has a similar life habit to trochus, was relatively common. Green snail (*Turbo marmoratus*), a species commonly found in Rarumana in the past, was not noted in this survey and is considered commercially extinct. Blacklip pearl oysters (*Pinctada margaritifera*) were common at Rarumana and the area has potential for the development of pearl farming based on wild-spat collection.

Rarumana is close to the centre of biodiversity in the Pacific; however, only 14 species of commercial sea cucumbers were recorded. Distribution was patchy and densities of commercial species were extremely low. The picture of most sea cucumber species and species groups presented by these records is extremely bleak. The long history of the sea cucumber fishery in the Pacific suggests that these fisheries can bounce back from heavy fishing, but the Rarumana stocks are some of the most depleted found in the PROCFish Pacific overview.

Recommendations for Rarumana

- Community fisheries management projects need to be established, to ensure a precautionary approach to resource use. Marine protected areas should be established around the island to maintain biodiversity and productivity of local resources.

- Actions need to be taken to reduce and control poaching activities.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Rarumana fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- The subsistence needs of the community for finfish and invertebrates are extremely high and the exploitation level of a number of selected target invertebrate species is also high. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

- The high dependency on marine resources for food will remain and its impact on the Rarumana marine resources needs to be wisely managed, with finfish and invertebrate stocks carefully monitored in order to maintain the present level of fisheries for sustenance and social reasons.

- Cooperation among governmental, NGO and other external institutions, and the Rarumana community needs to be fostered in order to ensure the success of improved fisheries management.

- For successful management, giant clams need to be maintained at higher density and include larger-sized individuals to spawn and reproduce effectively.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha. There is presently no scope for commercial trochus fishing at Rarumana, until the recommended threshold is reached at which managers might consider commercial fishing.

- Drastic management actions are needed to ensure there is a future for the sea cucumber fishery in Rarumana, which is among the most depleted in the entire PROCFish study across the Pacific. The fishery will need to be closed for a considerable period (up to 10 years) in the hope of re-building viable productivity in the fishery.

Results of fieldwork at Chubikopi

The village of Chubikopi is located in the north-eastern part of Marovo Island, Western Province, and includes Marovo Island, surrounding islets in the lagoon and barrier islands north of the Karikana passage (Karikana islands behind Charapoana). Marovo lagoon is semi-enclosed by a number of long, slender barrier islands. On the ocean-facing side of these barrier islands are steep vertical walls, which drop straight into the abyss. Deep channels between these barrier islands act as a medium of water exchange between the lagoon and the ocean. In general, water clarity in the areas surveyed was low or murky, increasing in turbidity from behind the barrier islands to the mainland. Waters immediately outside of the barrier islands or ocean-facing are very clear by comparison. Thick mangrove forests are found on Marovo Island and the mainland, while other islets in the lagoon and the barrier islands have few mangrove forests. Reef flats surrounding the islands including the inner, mid and outer parts of the study sites are quite narrow. There is high coral diversity and healthy coral growth; however, live-coral cover was low-to-moderate.

The Chubikopi community is an isolated, rural coastal area determined by traditional and religious institutions. People have access to agricultural land and marine resources. However, due to its distance from major markets: Gizo in Western Province and Honiara in Guadalcanal, commercialisation of fisheries produce is limited to the fortnightly visits of middlemen and agents, who control prices and keep them low.

Socioeconomics: Chubikopi

Chubikopi's population is highly dependent on its marine resources for home consumption, but only to a small degree for income generation. The distance to the urban markets of Gizo and Honiara, lack of ice and preservation facilities, and low prices for fisheries produce, all hinder any regular and larger-scale marketing of catch. Consumption of fresh fish is high (109.5 kg/person/year) and that of invertebrates (~9 kg/person/year) moderate. There are no strong gender roles in fisheries. However, male fishers fish more the fishing grounds further from shore. Males also dive exclusively for certain invertebrate species, while females only dive occasionally if the situation demands during their gleaning trips.

Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes. Castnets and handlines are the main methods used in the sheltered coastal reef and lagoon. Outer-reef fishing often involves deep-bottom lining, trolling, and longlining but also handlining and the use of spears and drop stones. Catches of giant clams, crabs (*Scylla serrata*), and lobsters account for most of the annual harvest (wet weight) of invertebrates.

Finfish resources: Chubikopi

Although the reef habitat seemed relatively rich in Chubikopi, the finfish community was found to be rather poor in both composition and abundance. Density, size and biomass values were consistently lower than at other sites. Coastal reefs appeared to be the poorest of all habitats and poorest compared to the coastal reefs of Marau and Rarumana; biomass was less than one-fifth of the biomass recorded in Marau. Only outer reefs displayed a biodiversity which was second-highest to biodiversity in the outer reefs in Rarumana. The average sizes of target carnivores (Lethrinidae, Mullidae and Scaridae especially) were reduced; these reduced sizes, together with the lower numbers and biomass in all reefs, were the first visible signs of fishing impact.

The condition of Marovo lagoon seriously declined after heavy logging started as a major industry in the region. Complaints from local people and visitors were common concerning the condition of the water and the reefs inside the lagoon. Outer reefs in Chubikopi were rather complex, made of walls and outer lagoonal-type pools, hosting small and rare schools of *Bolbometopon muricatum*.

Invertebrate resources: Chubikopi

The lagoon at Chubikopi provided suitable habitat for the full range of giant clams found in Solomon Islands, although the river run-off may cause unsuitable conditions after heavy rains. The range of clams recorded at the Chubikopi site was restricted, with both *Tridacna derasa* and *T. gigas* not recorded in the survey. *T. crocea* had moderate densities at a few locations (1.3 clams per 10 m^2), but *T. maxima*, *T. squamosa* and *Hippopus hippopus* were rare and at lower density than expected. Although *T. maxima* displayed a relatively ‘full’ range of size classes, the larger shell sizes of *T. crocea* were noticeably impacted, and no small *T. squamosa* were noted. Presence of young clams indicated that successful spawning and recruitment were occurring.

Local reef conditions at Chubikopi constitute a moderate area for adult and juvenile trochus (*Trochus niloticus*). Trochus were widely distributed on the reefs around Chubikopi; however, density was very low, and no high-density spawning aggregations were identified. Size class information revealed that recruitment of trochus was not strong. Stocks of large-sized trochus were depleted, despite regulations being in place to protect these larger shells. The low commercial value green topshell (*Tectus pyramis*) which has a similar life habit to trochus, was relatively common, also the blacklip pearl oyster (*Pinctada margaritifera*). Green snail (*Turbo marmoratus*), a species commonly recorded in Solomon Islands, was not noted and is considered commercially extinct in Chubikopi.

The range of protected shallow-water and reef habitats made Chubikopi a suitable site for the full range of sea cucumber species typical of Solomon Islands. The number of commercial sea cucumber species recorded at Chubikopi was relatively low (n = 17). Many species that are typically recorded in the PROCFish surveys in the Pacific were absent (e.g. black teatfish, *Holothuria nobilis*, and sandfish, *H. scabra*). The distribution of sea cucumbers was patchy and the density of commercial species was extremely low. The picture of most sea cucumber species and species groups presented by these records is extremely bleak.

Recommendations for Chubikopi

- Community fisheries management projects need to be continued and improved with a precautionary approach to resource use advised. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Chubikopi fishing ground and Marovo lagoon that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- The high population density and the high seafood consumption already results in high fishing pressure per available reef and total fishing ground. Rather than further exploiting marine resources, options to improve marketing and create alternative income opportunities for local people, such as the traditional and marketable wood-carving industry in Chubikopi, need to be explored.

- Cooperation among governmental, NGO and other external institutions, and the Chubikopi community needs to be fostered in order to ensure the success of improved fisheries management.

- Protection measures should be implemented to rebuild the numbers and sizes of clams and reverse the decline. For successful stock management, clams, especially the larger-sized individuals, need to be maintained at higher density than was noted at this section of Marovo lagoon.

- There is presently no scope for commercial trochus fishing at Chubikopi. Strict protection of trochus stocks is needed until the density of trochus in the main aggregations reaches 500–600 /ha. To assist recovery, it may be worthwhile moving some of the remaining adult trochus to make aggregations in areas where they previously occurred.

- Drastic management actions are needed to ensure there is a future for the sea cucumber fishery in Chubikopi, which is among the most depleted in the entire PROCFish study across the Pacific. The fishery will need to be closed for a considerable period (up to 10 years) in the hope of re-building viable productivity in the fishery.

RÉSUMÉ

Les agents de la composante côtière du Programme régional de développement des pêches océaniques et côtières (PROCFish/C) ont effectué des travaux de terrain sur quatre sites des Îles Salomon, de juillet à septembre 2006 et en décembre 2006. Les Îles Salomon figurent parmi les 17 États et Territoires insulaires océaniens où des enquêtes ont été réalisées de manière échelonnée sur 5 à 6 ans, au titre de PROCFish ou de son programme connexe, CoFish (Programme de développement de la pêche côtière dans le Pacifique)[4].

Les enquêtes visaient à réunir des informations de référence sur l'état des pêcheries récifale pour combler l'énorme déficit d'information qui fait obstacle à la bonne gestion de ces pêcheries.

D'autres réalisations sont à inscrire au crédit du programme :

- la mise en œuvre de la première évaluation comparative globale des ressources récifales (poissons, invertébrés et paramètres socio-économiques) jamais réalisée dans plusieurs États et Territoires insulaires océaniens au moyen de méthodes identiques sur chaque site ;
- la diffusion de rapports sur les pays qui comprennent un ensemble de « profils des pêcheries récifales » pour les différents sites de chaque pays afin de fournir les informations nécessaires à la planification de la gestion et du développement de la pêche côtière ;
- l'élaboration d'un ensemble d'indicateurs (ou de points de référence sur l'état des pêcheries) offrant des orientations pour l'élaboration de plans locaux et nationaux de gestion des pêcheries récifales et des programmes de suivi ; et
- la mise au point de systèmes de gestion des données et de l'information, dont des bases de données régionales et nationales.

Les enquêtes conduites aux Îles Salomon comprenaient trois volets (poissons, invertébrés et paramètres socio-économiques) pour chaque site. L'équipe, composée de cinq chargés de recherche et de plusieurs stagiaires locaux détachés par le Service national des pêches et *The Nature Conservancy*, a enquêté sur deux sites par sortie. Les travaux de terrain ont permis de renforcer les capacités des correspondants locaux qui se sont familiarisés avec les méthodes d'enquête et d'inventaire employées dans les domaines précités, en particulier la collecte de données et leur saisie dans la base de données du Programme.

Quatre sites ont été retenus aux Îles Salomon : Nggela, Marau, Rarumana et Chubikopi. Chacun devait satisfaire aux critères énoncés ci-après :

- la pêche récifale devait y être effectivement pratiquée ;
- le site devait être représentatif du pays ;
- le système devait être relativement fermé, c'est-à dire que les habitants du site pêchaient dans des zones bien définies ;
- la taille du site devait être appropriée ;
- le site devait abriter des habitats divers ;

[4] Les projets CoFish et PROCFish/C font partie du même programme d'action, CoFish ciblant Niue, Nauru, les États fédérés de Micronésie, Palau, les Îles Marshall et les Îles Cook (pays ACP bénéficiant d'un financement au titre du 9e FED) et PROCFish/C les pays bénéficiant de fonds alloués au titre du 8e FED (pays ACP : Îles Fidji, Tonga, Papouasie-Nouvelle-Guinée, Îles Salomon, Vanuatu, Samoa, Tuvalu et Kiribati, et collectivités françaises d'outre-mer : Nouvelle-Calédonie, Polynésie française et Wallis et Futuna (PTOM). C'est pourquoi les termes CoFish et PROCFish/C sont employés indifféremment dans tous les rapports de pays.

- il ne devait pas présenter de problèmes logistiques majeurs ;
- il devait avoir été étudié auparavant ; et
- il devait présenter un intérêt particulier pour le Service national des pêches des Îles Salomon.

Résultats des travaux de terrain effectués à Nggela

L'île de Sandfly est située à l'extrémité occidentale de l'île principale de Nggela, dont elle est séparée par un passage. Nos enquêtes portent essentiellement sur la partie occidentale de Sandfly, qui comprend Olevugha, Semege, Niumala, Mangalonga, Ravusodukosi et les îlots environnants. L'île et les îlots étudiés se caractérisent par des côtes découpées, héritées de leur passé géologique. La mangrove y est peu présente, à l'exception de quelques endroits isolés encerclant des baies semi-fermées. Les échanges d'eaux sont importants au niveau des îles, d'où une forte influence océanique et des eaux perpétuellement limpides. Les platiers récifaux sont en général étroits. Des infestations d'Acanthaster ont été observées sur certains récifs, ce qui, selon les pêcheurs, n'est pas un phénomène nouveau. Une partie importante des récifs concernés est déjà blanchie ou détériorée.

Située non loin d'Honiara et dotée d'un réseau de transports, quoiqu'imparfait, la communauté de Nggela est l'un des principaux fournisseurs de produits de la mer du marché d'Honiara. Les possibilités de conservation et de transformation des produits agricoles et de la pêche étant limitées en raison de l'absence d'électricité, ces derniers sont vendus à des intermédiaires et à des agents ou, plus rarement, directement aux clients, sur le marché d'Honiara.

Enquêtes socioéconomiques: Nggela

La population de Nggela est fortement tributaire des ressources halieutiques, dont elle tire revenus et nourriture. La consommation de poisson frais est élevée (98,6 kg/personne/an) et constitue la base de l'alimentation et la principale source d'apport protéique. L'agriculture, toutefois, est une source de revenus encore plus importante que la pêche et contribue de manière non négligeable à l'alimentation des familles. Les femmes sont les seules à pêcher exclusivement des invertébrés, tandis que les hommes sont les seuls à pêcher exclusivement du poisson. La plupart des pêcheurs des deux sexes prennent à la fois du poisson et des invertébrés.

Le poisson est surtout pêché dans le lagon et sur le récif côtier protégé, principalement à bord de pirogues sans moteur. Les quantités importantes de poisson pêchées sur le tombant récifal externe sont, pour l'essentiel, prises par des hommes pratiquant la pêche à des fins commerciales, souvent à bord de bateaux à moteur. La pêche au grand fond et la pêche pélagique engendrent également des revenus considérables. Le bénitier (notamment *Tridacna crocea* et *T. maxima*), *Holothuria* spp., *Pinna bicolor*, le troca, *Strombus* spp., l'oursin et la langouste constituent l'essentiel des prises annuelles d'invertébrés (en poids humide). Ces espèces sont prélevées à des fins commerciales ou de subsistance.

Ressources en poisson: Nggela

L'habitat récifal de Nggela est relativement riche. Les ressources en poisson du tombant récifal externe, seul type d'habitat à Nggela, y sont en meilleure santé que sur les trois autres tombants récifaux étudiés dans le pays. La densité, les rapports de tailles et la biomasse de poissons sont supérieurs aux valeurs relevées sur les autres sites. La structure trophique est dominée par les herbivores, principalement des acanthuridés, peut-être en raison de la couverture étendue de fonds durs. Le rapport de tailles moyen par famille indique que les stocks sont en bonne santé, puisque l'on enregistre des tailles supérieures à 55 % de la taille maximale chez la grande majorité des familles. À Nggela, les populations de lethrinidés, lutjanidés et mullidés sont importantes en biomasse et d'un niveau similaire aux populations de Marau.

Ressources en invertébrés: Nggela

On trouve à Nggela peu de récifs de faible profondeur convenant aux bénitiers. Par ailleurs, l'habitat n'est pas suffisamment diversifié pour abriter toutes les espèces de bénitiers des Îles Salomon. Les stocks de *Hippopus hippopus* sont peu importants, ce qui s'explique surtout par le type d'environnement. En revanche, les stocks de *Tridacna squamosa* et de *T. derasa* sont appauvris à un point critique. Quant à *T. gigas*, il a disparu au sens commercial'[5]. Malgré une gamme relativement étendue de classes de taille pour ce qui est de *T. maxima*, *T. crocea* et *T. squamosa*, les bénitiers sont peu abondants, et rares sont ceux de grande taille, ce qui laisse à penser que les stocks sont fortement affectés par la pêche.

Les récifs de Nggela offrent un habitat relativement étendu et adapté aux trocas adultes (*Trochus niloticus*, troca d'intérêt commercial) mais plus restreint aux juvéniles. On ne trouve pas de forte concentration de trocas. Les stocks de trocas de grande taille, indispensables à la production d'œufs, sont épuisés. En d'autres termes, il faudra attendre cinq ans ou plus avant qu'ils se régénèrent et retrouvent une biomasse suffisante pour être de nouveau productifs. Les stocks de *Tectus pyramis* (de faible valeur commerciale) et d'huîtres perlières aux lèvres noires, *Pinctada margaritifera*, sont relativement importants à Nggela. Le burgau (*Turbo marmoratus*), une espèce endémique fréquemment observée à Nggela lors des enquêtes précédentes, n'apparaît pas dans cette enquête et peut donc être considérée comme disparue au sens commercial.

Les holothuries sont bien réparties sur l'ensemble du site, même si certaines espèces présentant une valeur commerciale moyenne ou élevée, telles que l'holothurie léopard (*Bohadschia argus*) ou l'holothurie noire à mamelles (*Holothuria nobilis*), sont peu communes. Il est inhabituel de constater que des espèces à faible valeur commerciale telles que *H. atra*, *H. edulis* et *B. vitiensis* enregistrent des densités relativement faibles. La faible densité observée chez la plupart des espèces d'holothuries semble exclure toute poursuite de la pêche à ce stade. En revanche, ce site soumis à l'influence océanique et aux mouvements d'eau convient bien à l'holothurie blanche à mamelles (*H. fuscogilva*), qui vit en eaux profondes et dont la valeur commerciale est élevée.

Recommandations pour Nggela

- Il convient de poursuivre les programmes existants de gestion communautaire de la pêche et de les améliorer en appliquant le principe de précaution à l'exploitation des ressources. Il est essentiel de continuer à créer de nouvelles aires marines protégées autour des îles inhabitées et difficiles d'accès.

[5] Dans le contexte de la présente enquête, cela signifie que la densité des bénitiers est si faible qu'ils ne peuvent être commercialisés et risquent de disparaîre à jamais des eaux de Nggela.

- Il faut trouver des indicateurs biologiques, halieutiques et/ou socio-économiques facilitant le suivi de l'état des ressources et la mise en œuvre de mesures de précaution pour certaines espèces d'invertébrés et de poissons. Il importe également, en complément des pratiques de gestion actuelles, de dresser la carte des zones à risque, c'est-à-dire des endroits, au sein de la zone de pêche de Nggela, qui sont potentiellement le plus exposés à la surpêche.

- La pression halieutique est d'ores et déjà extrêmement élevée sur les ressources en poisson et certaines espèces d'invertébrés. Plutôt que d'exploiter encore davantage ces ressources, mieux vaut réfléchir aux différentes manières de valoriser les produits issus de la pêche grâce aux techniques de conservation et de traitement afin d'optimiser leur commercialisation et de créer de nouvelles sources de revenu pour la population locale.

- Il faut intensifier la coopération entre la communauté, les pouvoirs publics, les ONG et d'autres institutions extérieures afin d'assurer le succès des mesures visant à améliorer la gestion de la pêche.

- Pour gérer au mieux les stocks de bénitiers, il faut augmenter et maintenir à un niveau de densité stable les populations, lesquelles doivent comprendre des individus de grande taille afin d'assurer un niveau de reproduction suffisant pour renouveler les stocks.

- Il convient d'imposer des mesures de protection draconiennes sur les stocks de trocas jusqu'à ce que les concentrations atteignent 500–600 individus par hectare.

- Il faut élaborer et mettre en œuvre des mesures de gestion des stocks d'holothuries, compte tenu de la faible densité observée chez la plupart des espèces.

Résultats des travaux de terrain effectués à Marau

Marau Sound (province de Guadalcanal) est un vaste lagon situé à l'extrémité orientale de Guadalcanal et doté de récifs frangeants entourant plusieurs groupes d'îles. Marau Sound et une partie de la côte nord-ouest sont les seuls endroits de la province où l'on trouve des platiers affleurants. Marau est ceinturé par un récif partiellement immergé en forme de croissant. À Marau, les îles situées à proximité de l'île principale sont bordées de mangroves denses, entrecoupées ici et là de platiers étroits (< 20 m de large). Les îles plus éloignées, face au large, renferment des platiers plus larges, qui peuvent couvrir jusqu'à 500 m par endroits. Le taux de renouvellement de l'eau est élevé au niveau des îlots, ce qui explique que les eaux du lagon soient perpétuellement limpides. On note une grande diversité de coraux dont la croissance est saine. Toutefois, la couverture de corail vivant est faible à modérée. Des infestations d'Acanthaster d'intensité modérée à élevée affectent plusieurs récifs de Marau.

La communauté de Marau est une communauté côtière rurale isolée, répartie sur plusieurs îlots et une partie de l'île principale, dans la province de Guadalcanal. Son isolement est accru par l'insuffisance et le coût des transports vers les centres principaux. Du fait de l'isolement, de l'insuffisance des transports et des infrastructures commerciales, du manque d'accès à l'électricité, à la glace ou à d'autres moyens de conservation, et de la disparition du marché de Marau, la population vit en autarcie avec de maigres revenus et peu de perspectives de changement, les salaires et le pouvoir d'achat des habitants de Marau ne leur permettant pas d'acquérir des aliments importés. Des intermédiaires et des agents viennent à

Marau tous les quinze jours pour se procurer du poisson et des invertébrés. Une vente de trocas est organisée une fois par mois.

Enquêtes socioéconomiques: Marau

La population de Marau est fortement tributaire des ressources halieutiques, dont elle tire revenus et nourriture. La consommation de poisson frais est élevée (101 kg/personne/an) et représente la base de l'alimentation et la principale source d'apport protéique. Il n'y a pas de rôle traditionnellement assigné à l'un ou l'autre sexe, bien qu'il soit interdit aux femmes de se livrer à certaines activités de pêche ou de se rendre dans certains endroits. Les femmes sont les seules à pêcher exclusivement des invertébrés, tandis que les hommes sont les seuls à pêcher exclusivement du poisson. La plupart des pêcheurs des deux sexes prennent à la fois du poisson et des invertébrés.

Le poisson est surtout pêché dans le lagon et sur le récif côtier protégé, principalement à bord de pirogues sans moteur. Les quantités importantes de poisson pêchées sur le tombant récifal externe sont, pour l'essentiel, prises par des hommes pratiquant la pêche à des fins commerciales. Le bénitier, en particulier *Tridacna maxima*, le crabe *Scylla serrata*, le troca *Sipunduculus* spp., *Holothuria* spp., *Tectus* spp. et *Strombus* spp. représentent l'essentiel des prises annuelles d'invertébrés (en poids humide). Ces espèces sont prélevées à des fins commerciales ou de subsistance.

Ressources en poisson: Marau

L'habitat récifal de Marau est relativement riche et abrite des ressources en poisson assez diversifiées et plus riches que les autres sites étudiés. Les valeurs enregistrées en matière de densité, de rapports de tailles et de biomasse de poissons y sont supérieures à tous les autres sites. La structure trophique comprend de nombreux carnivores, dont la biomasse est plus importante que celle des herbivores. Bien que les mérous (serranidés) soient rares, les vivaneaux (lutjanidés), les empereurs (lethrinidés) et les mulets (mullidés) sont présents en grands nombres dans tous les habitats récifaux. Les premiers résultats laissent à penser que l'impact de la pêche y est peut-être inférieur à la moyenne, notamment en ce qui concerne les espèces carnivores. Quant aux herbivores, on observe une majorité d'acanthuridés et relativement peu de scaridés. Les tailles moyennes des poissons semblent élevées, quel que soit l'habitat, ce qui est une indication supplémentaire du bon état des stocks. L'arrière-récif est l'habitat le mieux préservé, tandis que les récifs intermédiaires présentent les premiers signes d'une diminution des stocks, les poissons y étant plus petits et moins nombreux.

Ressources en invertébrés: Marau

Le récif lagonaire protégé de Marau, à la structure complexe et aux échanges d'eau importants, convient particulièrement bien aux bénitiers. On note la présence de bénitiers en quantité moyenne, mais leur densité est en général faible au vu du milieu, particulièrement adapté. Malgré une gamme relativement étendue de classes de taille pour ce qui est de *T. maxima*, *T. crocea* et *T. squamosa*, les bénitiers sont relativement peu abondants, notamment près du rivage, et rares sont ceux de grande taille, ce qui laisse à penser que les stocks sont fortement affectés par la pêche.

Les récifs de Marau offrent un habitat étendu et adapté aux trocas (*Trochus niloticus*), qu'ils soient adultes ou juvéniles. Ils sont largement répandus sur les récifs facilement accessibles, mais aucune concentration n'a été observée à l'extérieur du récif barrière. La population actuelle comprend quelques rares individus âgés (> 11 cm de largeur à la base). Le burgau *Tectus pyramis*, à faible valeur commerciale, et l'huître perlière aux lèvres noires, *Pinctada margaritifera*, sont relativement communs à Marau. Le burgau *Turbo marmoratus*, une espèce endémique fréquemment observée à Marau lors des enquêtes précédentes, n'apparaît pas dans cette enquête et peut donc être considérée comme disparu au sens commercial.

Les holothuries sont bien réparties sur l'ensemble du site, même si certaines espèces présentant une valeur commerciale moyenne ou élevée, telles que l'holothurie léopard (*Bohadschia argus*) et l'holothurie noire à mamelles (*Holothuria nobilis*), sont peu communes. Il est inhabituel de constater que des espèces à faible valeur commerciale telles que *H. atra*, *H. edulis* et *B. vitiensis* enregistrent également des densités relativement faibles. L'influence océanique sur le site convient à l'holothurie blanche à mamelles, *H. fuscogilva*, qui vit en eaux profondes et qui est moyennement représentée. Sous réserve d'une gestion minutieuse de l'exploitation, il est possible de procéder à des prélèvements réguliers de cette espèce à Marau. Cependant, en règle générale, la faible densité observée chez la plupart des espèces d'holothuries et des groupes d'espèces semble exclure toute poursuite de la pêche à ce stade.

Recommandations pour Marau

- Il convient de poursuivre les programmes existants de gestion communautaire de la pêche et de les améliorer en appliquant le principe de précaution à l'exploitation des ressources. Il est essentiel de continuer à créer de nouvelles aires marines protégées autour des îles inhabitées et difficiles d'accès.

- Il faut trouver des indicateurs biologiques, halieutiques et/ou socio-économiques facilitant le suivi de l'état des ressources et la mise en œuvre des mesures de précaution pour certaines espèces d'invertébrés et de poissons. Il importe également, en complément des pratiques de gestion actuelles, de dresser la carte des zones à risque, c'est-à-dire des endroits, au sein de la zone de pêche de Marau, qui sont potentiellement le plus exposés à la surpêche.

- La pression halieutique est d'ores et déjà extrêmement élevée sur les ressources en poisson et certaines espèces d'invertébrés. Plutôt que d'exploiter encore davantage ces ressources, mieux vaut réfléchir aux différentes manières de valoriser les produits issus de la pêche grâce aux techniques de conservation et de traitement afin d'optimiser leur commercialisation et de créer de nouvelles sources de revenu pour la population locale.

- Les récifs intermédiaires sont les plus appauvris des quatre habitats étudiés et la pêche de poissons doit y être évitée. Une exploitation durable des ressources récifales en poissons est néanmoins envisageable, notamment sur l'arrière-récif et le récif côtier, à condition de mettre en place des mesures de gestion adéquates et de surveiller régulièrement l'état desdites ressources

- Il faut intensifier la coopération entre la communauté, les pouvoirs publics, les ONG et d'autres institutions extérieures afin d'assurer le succès des mesures visant à améliorer la gestion de la pêche.

- Pour gérer au mieux les stocks de bénitiers, il faut augmenter et maintenir à un niveau de densité stable les populations, lesquelles doivent comprendre des individus de grande taille afin d'assurer un niveau de reproduction suffisant pour renouveler les stocks.

- Il convient d'imposer des mesures de protection draconiennes sur les stocks de trocas jusqu'à ce que les concentrations atteignent 500–600 individus par hectare.

- Il faut élaborer et mettre en œuvre des mesures de gestion des stocks d'holothuries, compte tenu de la faible densité observée chez la plupart des espèces.

Résultats des travaux de terrain effectués à Rarumana

La communauté de Rarumana englobe plusieurs villages, disséminés le long de la côte de la partie septentrionale de l'île de Parara (province occidentale). On estimait la population de la communauté à plus de 1000 habitants en 2006. La plupart d'entre eux sont membres de l'Église unifiée. Notre étude a été menée sur les îlots et les récifs intra-lagonaires bordant la communauté. Les échanges d'eau entre l'océan et le lagon se font à des débits élevés. Il s'ensuit que les eaux lagonaires sont moyennement limpides. En conséquence, il n'y a pas de mangrove sur le site étudié, hormis à certains endroits situés le long des rives et des baies à l'extérieur des zones étudiées. Les platiers récifaux de Rarumana sont en général étroits, à l'exception des tombants récifaux externes, bien plus larges (100–300 m). On note la présence d'une bonne couverture corallienne et d'une croissance saine, en particulier sur les parties centrale et externe du lagon.

La communauté de Rarumana est une communauté côtière rurale isolée pour laquelle les débouchés liés à la vente des produits de la pêche sont limités : le marché de Gizo est saturé, l'écoulement des produits sur le marché local difficile et les coûts de transport jusqu'au marché d'Honiara élevés. L'absence d'électricité et, partant, la difficulté d'obtenir de la glace ne facilitent pas le transport de produits de la pêche frais ni leur traitement à grande échelle. La communauté dépend de la production agricole, qui représente également la principale source de revenus monétaires. Le pouvoir d'achat des villageois ne leur permet pas d'acquérir des aliments importés ou d'autres produits en grande quantité. Outre la pêche, d'autres activités commerciales locales telles que la préparation et la vente d'aliments, ainsi que la vente de la chaux et de la noix de bétel, sont également source de revenus.

Enquêtes socioéconomiques: Rarumana

La population de Rarumana est fortement tributaire des ressources halieutiques, dont elle tire nourriture et, dans une moindre mesure, revenus. La consommation de poisson frais est élevée (environ 111 kg/personne/an) et représente la base de l'alimentation et la principale source d'apport protéique. Il n'y a pas de rôle traditionnellement assigné à l'un ou l'autre sexe, même si les femmes sont les seules à pêcher exclusivement des invertébrés, tandis que les hommes sont les seuls à pêcher exclusivement du poisson. La plupart des pêcheurs des deux sexes prennent à la fois du poisson et des invertébrés.

Le poisson est surtout pêché dans le lagon et sur le récif côtier protégé, principalement à bord de pirogues sans moteur. Les quantités importantes de poisson pêchées sur le tombant récifal externe sont, pour l'essentiel, pêchées par des hommes, qui en réservent une partie à des fins commerciales. La ligne à main et le fusil-harpon sont les principaux équipements utilisés dans presque tous les habitats, tandis que les lignes pour la pêche profonde et les lignes de traîne sont utilisées uniquement pour le tombant récifal externe. Le bénitier, en particulier *Hippopus hippopus* et *Tridacna crocea* mais également d'autres Tridacnidae, *Strombus* sp. et *Charonia tritoris* représentent l'essentiel des prises annuelles d'invertébrés (en poids humide). La plupart des invertébrés pêchés sont uniquement destinés à la consommation des ménages.

Ressources en poisson: Rarumana

Il ressort des évaluations que les ressources en poisson de Rarumana sont en mauvais état par comparaison avec les valeurs moyennes enregistrées sur les autres sites étudiés aux îles Salomon. Une évaluation détaillée à l'échelle du récif révèle également que les valeurs enregistrées en matière de densité, de rapports de tailles et de biomasse de poissons y sont en général inférieures à celles de Marau et supérieures à celles de Chubikopi. Le tombant récifal externe abrite en revanche une biodiversité beaucoup plus riche que tous les autres habitats et sites étudiés. Sur l'arrière-récif et le tombant récifal externe, la structure trophique est dominée par les herbivores, notamment les acanthuridés et les scaridés, ce qui est révélateur d'une forte exploitation. Les carnivores (lutjanidés et lethrinidés) ne sont guère présents que sur l'arrière-récif et le tombant récifal externe. Les lethrinidés et les mullidés affichent des rapports de tailles bas, sans doute sous l'effet de la forte pression de pêche. On note également une tendance générale de réduction des tailles chez les lutjanidés du récif intermédiaire et les serranidés du récif côtier.

Ressources en invertébrés: Rarumana

Le lagon de Rarumana offre des conditions propices à toutes les espèces de bénitiers observées aux Îles Salomon. On note une présence et une densité de bénitiers moyennes au vu de la nature du milieu. La gamme « complète » des classes de taille a été observée pour *T. maxima* et *T. squamosa*, même si le nombre de bénitiers crocus (*T. crocea*) de grande taille a été visiblement réduit sous l'effet de la pression de pêche. La présence de juvéniles témoigne de l'aboutissement du frai et du recrutement, mais la faible abondance et la raréfaction des bénitiers de grande taille indiquent que ces derniers subissent une forte pression de pêche.

Les récifs de Rarumana offrent un habitat étendu et adapté aux trocas (*Trochus niloticus*), adultes ou juvéniles, qui sont largement répandus sur les récifs facilement accessibles aux pêcheurs. Les perspectives générales du secteur sont cependant défavorables en raison de la très faible densité enregistrée et de l'absence de forte concentration de trocas en période de frai. Les classes de taille recensées mettent en évidence un faible taux de recrutement. Les captures ont globalement réduit la densité des stocks sur la plupart des sites et, partant, limité la possibilité de voir apparaître de nouveaux juvéniles. Le burgau à faible valeur commerciale *Tectus pyramis*, dont le mode de vie est similaire à celui du troca, est relativement commun à Rarumana. Le burgau *Turbo marmoratus*, fréquemment observé lors des enquêtes précédentes, n'apparaît pas dans cette enquête et peut donc être considéré comme disparu au sens commercial. L'huître perlière aux lèvres noires, *Pinctada margaritifera*, est abondante à Rarumana et l'on peut envisager de développer la perliculture en s'appuyant sur la collecte de naissains en milieu naturel.

Rarumana se trouve à proximité du centre de la biodiversité dans le Pacifique. Toutefois, seules 14 espèces d'holothuries d'intérêt commercial y ont été enregistrées. Elles sont inégalement réparties et leur densité est très faible. L'étude réalisée laisse entrevoir des perspectives d'avenir sombres pour la plupart des espèces et des groupes d'espèces d'holothuries. La pêche d'holothuries appartient depuis longtemps à la tradition océanienne, et l'histoire a montré que le secteur a la capacité de redémarrer après une période de pêche intensive. Il faut noter cependant que les stocks de Rarumana figurent parmi les plus appauvris de tous ceux étudiés en Océanie dans le cadre de PROCFish.

Recommandations pour Rarumana

- Il convient de mettre en place des programmes de gestion communautaire de la pêche en appliquant le principe de précaution à l'exploitation des ressources. Il est essentiel de créer des aires marines protégées autour de l'île de sorte à préserver la biodiversité et la productivité des ressources locales.

- Il faut prendre des mesures pour réduire et maîtriser les activités de braconnage.

- Il faut trouver des indicateurs biologiques, halieutiques et/ou socio-économiques facilitant le suivi de l'état des ressources et la mise en œuvre de mesures de précaution pour certaines espèces d'invertébrés et de poissons. Il importe également, en complément des pratiques de gestion actuelles, de dresser la carte des zones à risque, c'est-à-dire des endroits, au sein de la zone de pêche de Rarumana, qui sont potentiellement le plus exposés à la surpêche.

- La communauté de Rarumana est largement tributaire des poissons et des invertébrés pour sa subsistance, et le niveau d'exploitation des stocks de plusieurs espèces d'invertébrés ciblées est élevé. Plutôt que d'exploiter encore davantage ces ressources, mieux vaut réfléchir aux différentes manières de valoriser les produits issus de la pêche grâce aux techniques de conservation et de traitement afin d'optimiser leur commercialisation et de créer de nouvelles sources de revenu pour la population locale.

- Il convient de gérer judicieusement la forte dépendance alimentaire de la communauté par rapport aux ressources halieutiques et son incidence sur lesdites ressources en surveillant attentivement les stocks de poissons et d'invertébrés de manière à maintenir un niveau d'exploitation stable des ressources et satisfaire ainsi les besoins de subsistance de la communauté et le respect des obligations sociales.

- Il faut intensifier la coopération entre la communauté, les pouvoirs publics, les ONG et d'autres instances extérieures afin d'assurer le succès des mesures visant à améliorer la gestion de la pêche.

- Pour gérer au mieux les stocks de bénitiers, il faut augmenter et maintenir à un niveau de densité stable les populations, lesquelles doivent comprendre des individus de grande taille afin d'assurer un niveau de reproduction suffisant pour renouveler les stocks.

- Il convient d'imposer des mesures de protection draconiennes sur les stocks de trocas jusqu'à ce que les concentrations atteignent 500–600 individus par hectare. À l'heure actuelle, et tant que le niveau de concentration recommandé par les directeurs des pêches ne sera pas atteint, il n'est pas envisageable de pratiquer la pêche du troca à des fins commerciales à Rarumana.

- Il faut élaborer et mettre en œuvre des mesures de gestion drastiques des stocks d'holothuries afin d'assurer l'avenir du secteur, le site de Rarumana étant le plus appauvri de tous les sites océaniens étudiés dans le cadre de PROCFish. La pêche d'holothuries devra être interdite pendant une longue période (jusqu'à dix ans) si l'on veut espérer relancer la production de manière durable.

Résultats des travaux de terrain effectués à Chubikopi

Le village de Chubikopi est situé au nord-est de l'île de Marovo (province occidentale) et englobe cette dernière, les îlots avoisinants du lagon et les îles-barrière situées au nord du passage de Karikana (appelées « îles Karikana », derrière Charapoana). Le lagon de Marovo, semi-fermé, est bordé de plusieurs îles-barrière de forme allongée et étroite. La partie faisant face à l'océan se caractérise par des falaises abruptes qui tombent à pic dans l'océan, jusqu'aux fonds abyssaux. Les îles-barrière sont séparées par des chenaux profonds qui favorisent les échanges d'eau entre le lagon et l'océan. En règle générale, les eaux apparaissent peu limpides, voire troubles, au fur et à mesure que l'on s'éloigne des îles-barrière pour se rapprocher de l'île principale. Par comparaison, les eaux situées juste au-delà des îles-barrière ou face à l'océan sont d'une grande limpidité. Des mangroves denses couvrent une partie de l'île de Marovo et de l'île principale, tandis que d'autres îlots du lagon et les îles-barrière comptent peu de mangroves. Les platiers récifaux entourant les îles sont assez étroits, y compris les parties intérieures, extérieures et celles situées au milieu des sites étudiés. On note une grande diversité de coraux dont la croissance est saine. Toutefois, la couverture de corail vivant est faible à modérée.

La communauté de Chubikopi est une communauté côtière rurale isolée, définie par les institutions traditionnelles et religieuses. La population est en mesure d'exploiter les terres agricoles et les ressources halieutiques. Toutefois, du fait de l'éloignement des marchés principaux (Gizo, dans la province occidentale, et Honiara, dans la province de Guadalcanal), les produits issus de la pêche ne peuvent être commercialisés que lors de la visite bimensuelle des intermédiaires et des agents, lesquels régulent les prix à la baisse.

Enquêtes socioéconomiques: Chubikopi

La population de Chubikopi est fortement tributaire des ressources halieutiques, dont elle tire nourriture ainsi qu'une petite partie de ses revenus. L'éloignement des marchés urbains de Gizo et Honiara, le manque de glace et de moyens de conservation ainsi que les prix bas empêchent la vente régulière et à plus grande échelle des produits de la mer. La consommation de poisson frais est élevée (109,5 kg/personne/an) et celle d'invertébrés (~ 9 kg/personne/an) moyenne. Il n'y a pas de rôle traditionnellement assigné à l'un ou l'autre sexe, bien que les hommes pêchent plus au large et sont les seuls à plonger pour pêcher certains invertébrés. Les femmes, elles, plongent seulement en tant que de besoin, lorsqu'elles sortent ramasser des coquillages.

Le poisson est surtout pêché dans le lagon et sur le récif côtier protégé, principalement à bord de pirogues sans moteur. L'épervier et la ligne à main sont les principales techniques employées sur le récif côtier protégé et dans le lagon. Sur le tombant récifal externe, on pratique souvent la pêche à la palangrotte, la pêche à la traîne et la pêche à la palangre, mais on a également recours à la ligne à main, au fusil-harpon et aux pierres. Le bénitier, le crabe *Scylla serrata* et la langouste représentent l'essentiel des prises annuelles d'invertébrés (en poids humide).

Ressources en poisson: Chubikopi

Bien que l'habitat récifal de Chubikopi soit relativement riche, on note une communauté de poissons plutôt restreinte, tant par sa composition que par son abondance. La densité, les rapports de tailles et la biomasse de poissons sont constamment inférieurs aux valeurs relevées sur les autres sites. Les récifs côtiers enregistrent les valeurs les plus faibles, tous habitats confondus, et s'inscrivent en-deça des valeurs enregistrées sur les récifs côtiers de Marau ou Rarumana; ainsi, la biomasse de poissons y est cinq fois moins importante qu'à Marau. S'agissant de la biodiversité, les tombants récifaux externes occupent la deuxième place, après les tombants récifaux externes de Rarumana. Les espèces carnivores ciblées (en particulier les lethrinidés, les mullidés et les scaridés) sont de taille plus réduite en moyenne. Les faibles valeurs enregistrées en termes de tailles, d'effectifs et de biomasse sont l'un des premiers signes de l'impact de la pêche.

L'état du lagon de Marovo s'est considérablement détérioré après l'intensification de l'exploitation forestière dans la région. Nombre d'habitants et de visiteurs se sont plaints de la mauvaise qualité de l'eau et de la dégradation des récifs dans le lagon. Les tombants récifaux externes de Chubikopi présentent une structure assez complexe, où se mêlent parois rocheuses et bassins extérieurs de type lagonaire. On y trouve de petits bancs de *Bolbometopon muricatum*, rarement observés ailleurs.

Ressources en invertébrés: Chubikopi

Le lagon de Chubikopi convient à toutes les espèces de bénitiers que l'on trouve aux Îles Salomon, même si les apports terrigènes des cours d'eau peuvent s'avérer préjudiciables, notamment en cas de fortes précipitations. On enregistre une gamme restreinte de bénitiers sur le site de Chubikopi et on constate l'absence de *Tridacna derasa* et de *T. gigas ; T. crocea* est présent en densité moyenne à plusieurs endroits (1,3 bénitiers sur 10 m^2). En revanche, *T. maxima*, *T. squamosa* et *Hippopus hippopus* sont rares et leur densité est plus faible que prévu. S'il est vrai que l'on trouve la gamme « complète » de classes de taille de *T. maxima*, on note une diminution significative du nombre de *T. crocea* de grande taille et l'absence totale de *T. squamosa* de petite taille. La présence de juvéniles témoigne cependant de l'aboutissement du frai et du recrutement.

Les récifs de Chubikopi offrent des conditions relativement propices aux trocas adultes et juvéniles (*Trochus niloticus*). Cependant, bien que les stocks de trocas y soient largement répandus, leur densité est très faible et aucune forte concentration de reproducteurs n'a été enregistrée. Les classes de taille recensées mettent en évidence un faible taux de recrutement. Malgré les mesures de protection mises en place, les stocks de trocas de grande taille sont appauvris. Le burgau à faible valeur commerciale *Tectus pyramis*, dont le mode de vie est similaire à celui du troca, est relativement commun à Chubikopi, tout comme l'huître perlière aux lèvres noires, *Pinctada margaritifera*. Le burgau *Turbo marmoratus*, fréquemment observé lors des enquêtes menées précédemment aux Îles Salomon, n'apparaît pas dans cette enquête et peut donc être considéré comme disparu au sens commercial.

Chubikopi offre une grande variété de zones protégées peu profondes et d'habitats récifaux et abrite la gamme complète des espèces d'holothuries que l'on trouve habituellement aux Îles Salomon. On y enregistre toutefois relativement peu d'espèces d'intérêt commercial (n = 17). Nombre d'espèces habituellement observées dans le cadre des études menées par PROCFish en Océanie sont absentes (p. ex. l'holothurie noires à mamelles *Holothuria nobilis* ou l'holothurie de sable *H. scabra*). La répartition des holothuries est inégale et on note une très faible densité d'espèces d'intérêt commercial. Il ressort de l'étude réalisée que la situation est critique pour la plupart des espèces et groupes d'espèces d'holothuries.

Recommandations pour Chubikopi

- Il convient de poursuivre les programmes existants de gestion communautaire des ressources et de les améliorer en appliquant le principe de précaution à l'exploitation des ressources. Il est essentiel de créer de nouvelles aires marines protégées autour des îles désertes et difficiles d'accès.

- Il faut trouver des indicateurs biologiques, halieutiques et/ou socio-économiques facilitant le suivi de l'état des ressources et la mise en œuvre de mesures de précaution pour certaines espèces d'invertébrés et de poissons. Il importe également, en complément des pratiques de gestion actuelles, de dresser la carte des zones à risque, c'est-à-dire des endroits, au sein de la zone de pêche de Chubikopi et du lagon de Marovo, qui sont potentiellement le plus exposés à la surpêche.

- La forte densité de population et la consommation élevée de produits de la mer entraînent d'ores et déjà une pression halieutique considérable sur les récifs et l'ensemble de la zone de pêche. Plutôt que d'exploiter encore davantage ces ressources, mieux vaut réfléchir aux différentes manières d'optimiser leur commercialisation et de créer de nouvelles sources de revenu pour la population locale, en misant par exemple sur la vente de sculptures sur bois traditionnelles.

- Il faut intensifier la coopération entre la communauté, les pouvoirs publics, les ONG et d'autres institutions extérieures afin d'assurer le succès des mesures visant à améliorer la gestion de la pêche.

- Il est nécessaire d'imposer des mesures de protection sur les bénitiers afin de reconstituer les stocks, encourager la croissance des individus et enrayer le déclin actuel. Pour gérer au mieux les stocks de bénitiers, il faut augmenter et maintenir à un niveau de densité stable les populations, notamment les individus de grande taille, et inverser ainsi la tendance observée dans cette partie du lagon de Marovo.

- À l'heure actuelle, il n'est pas envisageable de pratiquer la pêche du troca à des fins commerciales à Chubikopi. Il convient d'imposer des mesures de protection draconiennes sur les stocks de trocas jusqu'à ce que les concentrations atteignent 500–600 individus par hectare. Pour ce faire, il pourrait s'avérer judicieux de réinstaller un certain nombre de trocas adultes dans des endroits où des concentrations avaient auparavant été observées.

- Il faut élaborer et mettre en œuvre des mesures de gestion drastiques des stocks d'holothuries afin d'assurer l'avenir du secteur, le site de Chubikopi figurant parmi les plus appauvris de tous les sites océaniens étudiés dans le cadre de PROCFish. La pêche d'holothuries devra être interdite pendant une longue période (jusqu'à dix ans) si l'on veut espérer relancer la production de manière durable.

ACRONYMS

ACP	African, Caribbean and Pacific Group of States
AMCA	Arnavon Management Conservation Area
BdM	bêche-de-mer (or sea cucumber)
CITES	Convention on International Trade in Endangered Species
CMT	Customary Marine Tenure
CoFish	Pacific Regional Coastal Fisheries Development Programme
COTS	crown of thorns starfish
CPUE	catch per unit effort
DFMR	Department of Fisheries and Marine Research
Ds	day search
D-UVC	distance-sampling underwater visual census
DWFN	distant water fishing nations
EDF	European Development Fund
EEZ	exclusive economic zone
EU/EC	European Union/European Commission
FAD	fish aggregating device
FAO	Food and Agricultural Organization (UN)
FL	fork length
FSPI	Foundation of the Peoples of the South Pacific International
GKK	Gyogyo Kabushkiki Kaisha
GCRMN	Global Coastal Reef Monitoring Network
GPS	global positioning system
ha	hectare
HH	household
ICLARM	International Center for Living Aquatic Resources and Management (now WorldFish Center)
IUCN	International Union for the Conservation of Nature and Natural Resources (World Conservation Union)
IWP	International Waters Programme
LRFFT	live reef food fish trade
MAC	Marine Aquarium Council
MCRMP	Millennium Coral Reef Mapping Project
MGA	Main Group Archipelago
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPt	mother-of-pearl transect
MSA	medium-scale approach
NASA	National Aeronautics and Space Administration (USA)
NCA	nongeniculate coralline algae

NFD	National Fisheries Development
NGOs	non-governmental organisations
Ns	night search
OCT	Overseas Countries and Territories
OFCF	Overseas Fishery Cooperation Foundation
OGAF	Organisation des Agriculteurs Futuniens
PICTs	Pacific Island countries and territories
PL	fishing in passages at full moon
PNG	Papua New Guinea
PRISM	Pacific Regional Information System
PROCFish	Pacific Regional Oceanic and Coastal Fisheries Development programme
PROCFish/C	Pacific Regional Oceanic and Coastal Fisheries Development programme (coastal component)
RBt	reef-benthos transect
REA	Rapid Ecological Assessment
RFEP	Rural Fishing Enterprises Project
RFID	Reef Fisheries Integrated Database
RFs	reef-front search
RFs_w	reef-front search by walking
SBD	Solomon Island dollar(s)
SBq	soft-benthos infaunal quadrat
SCUBA	self-contained underwater breathing apparatus
SDA	Seventh Day Adventist
SE	standard error
SICFCS	Solomon Islands Coastal Marine Resources Consultancy Services
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
STL	Solomon Taiyo Limited
TAC	total allowable catch
TNC	The Nature Conservancy
USD	United States dollar(s)
USP	University of the South Pacific
WHO	World Health Organization
WWF	World Wildlife Fund

1. INTRODUCTION AND BACKGROUND

Pacific Island countries and territories (PICTs) have a combined exclusive economic zone (EEZ) of about 30 million km^2, with a total surface area of slightly more than 500,000 km^2. Many PICTs consider fishing to be an important means of gaining economic self-sufficiency. Although the absolute volume of landings from the Pacific Islands coastal fisheries sector (estimated at 100,000 tonnes per year, including subsistence fishing) is roughly an order of magnitude less than the million-tonne catch by the industrial oceanic tuna fishery, coastal fisheries continue to underpin livelihoods and food security.

SPC's Coastal Fisheries Management Programme provides technical support and advice to Pacific Island national fisheries agencies to assist in the sustainable management of inshore fisheries in the region.

1.1 The PROCFish and CoFish programmes

Managing coral reef fisheries in the Pacific Island region in the absence of robust scientific information on the status of the fishery presents a major difficulty. In order to address this, the European Union (EU) has funded two associated programmes:

1. The Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish); and
2. The Coastal Fisheries Development Programme (CoFish)

These programmes aim to provide the governments and community leaders of Pacific Island countries and territories with the basic information necessary to identify and alleviate critical problems inhibiting the better management and governance of reef fisheries and to plan appropriate future development.
The PROCFish programme works with the ACP countries: Fiji, Kiribati, Papua New Guinea, Vanuatu, Samoa, Solomon Islands, Tonga, Tuvalu, and the OCT French territories: French Polynesia, Wallis and Futuna, and New Caledonia, and is funded under European Development Fund (EDF) 8.
The CoFish programme works with the Cook Islands, Federated States of Micronesia, Marshall Islands, Nauru, Niue and Palau, and is funded under EDF 9.

The PROCFish/C (coastal component) and CoFish programmes are implementing the first comprehensive multi-country comparative assessment of reef fisheries (including resource and human components) ever undertaken in the Pacific Islands region using identical methodologies at each site. The goal is to provide baseline information on the status of reef fisheries, and to help fill the massive information gap that hinders the effective management of reef fisheries (Figure 1.1).

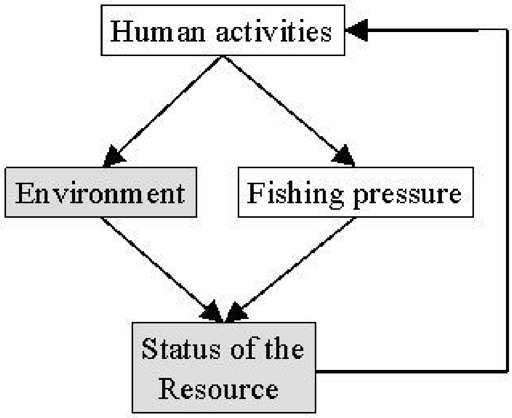

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the basis for taking a precautionary approach to management, with an adaptive long-term view.

* PROCFish/C denotes the coastal (as opposed to the oceanic) component of the PROCFish project.

Expected outputs of the project include:

- the first-ever region-wide comparative assessment of the status of reef fisheries using standardised and scientifically rigorous methods that enable comparisons among and within countries and territories;
- application and dissemination of results in country reports that comprise a set of 'reef fisheries profiles' for the sites in each country, in order to provide information for coastal fisheries development and management planning;
- development of a set of indicators (or fishery status reference points) to provide guidance when developing local and national reef fishery management plans and monitoring programmes;
- toolkits (manuals, software and training programmes) for assessing and monitoring reef fisheries, and an increase in the capacity of fisheries departments in participating countries in the use of standardised survey methodologies; and
- data and information management systems, including regional and national databases.

1.2 PROCFish/C and CoFish methodologies

A brief description of the survey methodologies is provided here. These methods are described in detail in Appendix 1.

1.2.1 Socioeconomic assessment

Socioeconomic surveys were based on fully structured, closed questionnaires comprising:

1. **a household survey** incorporating demographics, selected socioeconomic parameters, and consumption patterns for reef and lagoon fish, invertebrates and canned fish; and
2. **a survey of fishers** (finfish and invertebrate) incorporating data by habitat and/or specific fishery. The data collected addresses the catch, fishing strategies (e.g. location, gear used), and the purpose of the fishery (e.g. for consumption, sale or gift).

Socioeconomic assessments also relied on additional complementary data, including:

3. **a general questionnaire targeting key informants**, the purpose of which is to assess the overall characteristics of the site's fisheries (e.g. ownership and tenure, details of fishing

gear used, seasonality of species targeted, and compliance with legal and community rules); and

4. **finfish and invertebrate marketing questionnaires** that target agents, middlemen or buyers and sellers (shops, markets, etc.). Data collected include species, quality (process level), quantity, prices and costs, and clientele.

1.2.2 Finfish resource assessment

The status of finfish resources in selected sites was assessed by distance-sampling underwater visual census (D-UVC) (Labrosse *et al.* 2002). Briefly, the method involves recording the species name, abundance, body length and distance to the transect line of each fish or group of fish observed; the transect consists of a 50 m line, represented on the seafloor by an underwater tape (Figure 1.2). Mathematical models were then used to infer fish density (number of fish per unit area) and biomass (weight of fish per unit area) from the counts. Species surveyed included those reef fish of interest for marketing and/or consumption, and species that could potentially act as indicators of coral reef health (See Appendix 1.2 for a list of species.).

The medium-scale approach (MSA; Clua *et al.* 2006) was used to record habitat characteristics along transects where finfish were counted by D-UVC. The method consists of recording substrate parameters within twenty 5 m x 5 m quadrats located on both sides of the transect (Figure 1.2).

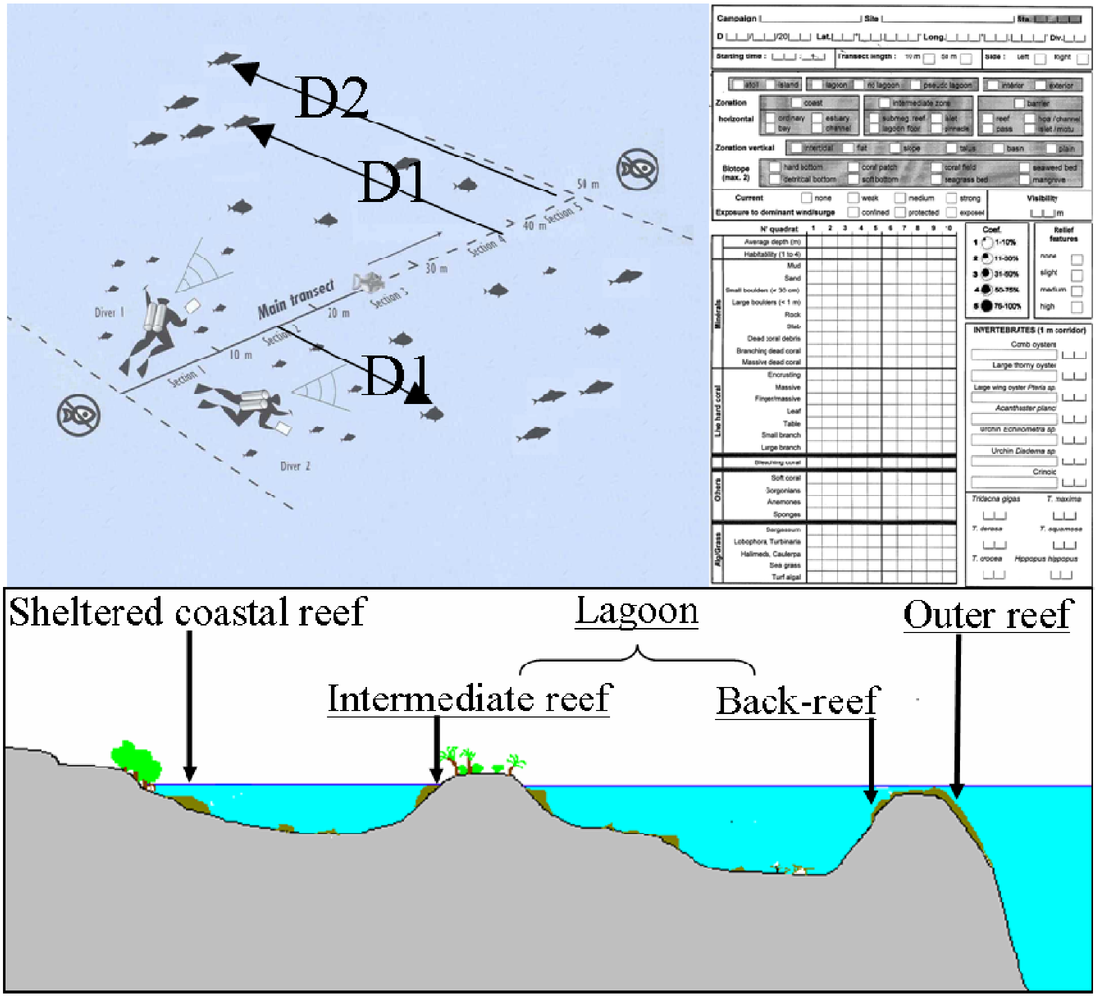

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys were conducted along 24 transects, with six transects in each of the four main geomorphologic coral reef structures: sheltered coastal reefs, intermediate reefs and back-reefs (both within the grouped 'lagoon reef' category used in the socioeconomic assessment), and outer reefs.

Fish and associated habitat parameters were recorded along 24 transects per site, with an equal number of transects located in each of the four main coral reef geomorphologic structures (sheltered coastal reef, intermediate reef, back-reef, and outer reef). The exact position of transects was determined in advance using satellite imagery; this assisted with locating the exact positions in the field and maximised accuracy. It also facilitated replication, which is important for monitoring purposes.

Maps provided by the NASA Millennium Coral Reef Mapping Project (MCRMP) were used to estimate the area of each type of geomorphologic structure present in each of the studied sites. Those areas were then used to scale (by weighted averages) the resource assessments at any spatial scale.

1.2.3 Invertebrate resource assessment

The status of invertebrate resources within a targeted habitat, or the status of a commercial species (or a group of species), was determined through:

1. resource measures at scales relevant to the fishing ground;
2. resource measures at scales relevant to the target species; and
3. concentrated assessments focussing on habitats and commercial species groups, with results that could be compared with other sites, in order to assess relative resource status.

The diversity and abundance of invertebrate species at the site were independently determined using a range of survey techniques, including broad-scale assessment (using the manta tow technique) and finer-scale assessment of specific reef and benthic habitats.

The main objective of the broad-scale assessment was to describe the large-scale distribution pattern of invertebrates (i.e. their relative rarity and patchiness) and, importantly, to identify target areas for further fine-scale assessment. Broad-scale assessments were used to record large sedentary invertebrates; transects were 300 m long × 2 m wide, across inshore, midshore and more exposed oceanic habitats (See Figure 1.3 (1).).[6]

Fine-scale assessments were conducted in target areas (areas with naturally higher abundance and/or the most suitable habitat) to specifically describe resource status. Fine-scale assessments were conducted of both reef (hard-bottom) and sandy (soft-bottom) areas to assess the range, size, and condition of invertebrate species present and to determine the nature and condition of the habitat with greater accuracy. These assessments were conducted using 40 m transects (1 m wide swathe, six replicates per station) recording most epi-benthic resources (those living on the bottom) and potential indicator species (mainly echinoderms) (See Figure 1.3 (2) and (3).).

In soft bottom areas, four 25 cm × 25 cm quadrats were dug at eight locations along a 40 m transect line to obtain a count of targeted infaunal molluscs (molluscs living in bottom sediments, which consist mainly of bivalves) (See Figure 1.3 (4).).

For trochus and bêche-de-mer fisheries, searches to assess aggregations were made in the surf zone along exposed reef edges (See Figures 1.3 (5) and (6).); and using SCUBA (7). On occasion, when time and conditions allowed, dives to 25–35 m were made to determine the availability of deeper-water sea cucumber populations (Figure 1.3 (8)). Night searches were conducted on inshore reefs to assess nocturnal sea cucumber species (See Appendix 1.3 for complete methods.).

[6] In collaboration with Dr Serge Andrefouet, IRD-Coreus Noumea and leader of the NASA Millennium project: http://imars.usf.edu/corals/index.html/.

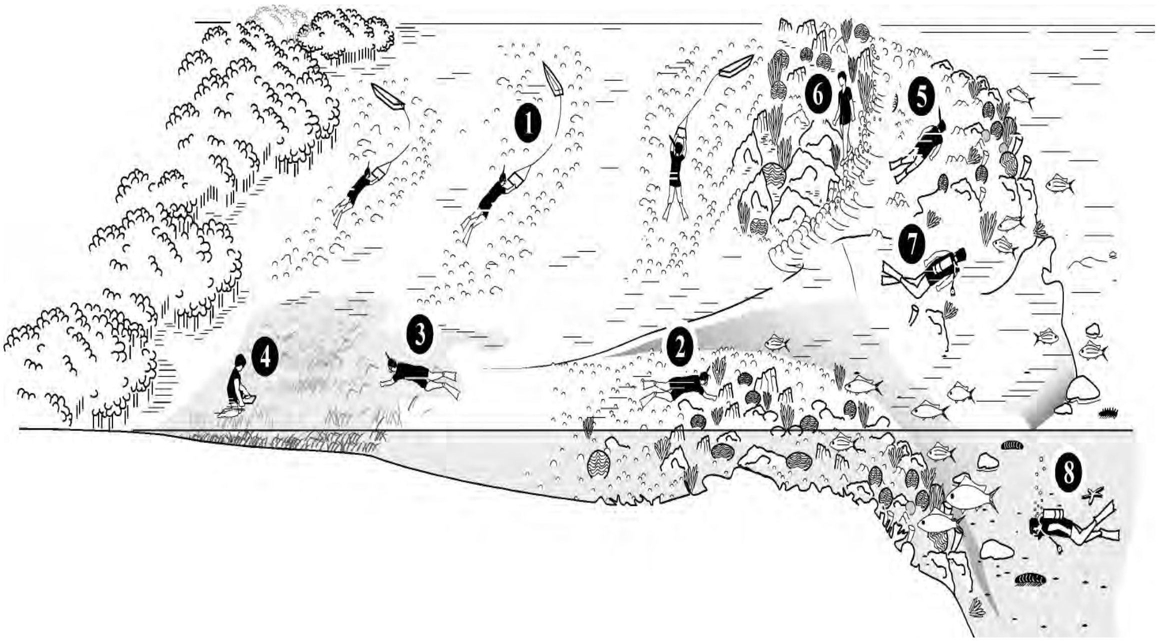

Figure 1.3: Assessment of invertebrate resources and associated environments.
Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrats to count targeted infaunal molluscs (4); searches to determine trochus and bêche-de-mer aggregations in the surf zone (5), reef edge (6), and using SCUBA (7); and deep dives to assess deep-water sea cucumber populations (8).

1.3 Solomon Islands

1.3.1 General

Solomon Islands lie in the southwest Pacific, to the east and south of Papua New Guinea (PNG). The Main Group Archipelago (MGA) is orientated northwest to southeast, stretching about 1700 km from Bougainville at the eastern tip of PNG to the northernmost islands of Vanuatu. The central archipelago of islands lies between latitudes 5°S and 12°S and longitudes 152°E and 163°E (Figure 1.4). It comprises a double chain of six large islands (Choiseul, Santa Isabel, New Georgia, Guadalcanal, Malaita and Makira) as well as many smaller ones, making a total of 997 islands. The country has a total land area of 28,370 km^2, a coastline of 4023 km, 642 km^2 of mangroves and 5750 km^2 of coral reefs (Skewes 1990; SICFCS 2002; Spalding *et al.* 2001). In addition there is an exclusive economic zone (EEZ) which covers 1340,000 km^2 (Chapman 2004).

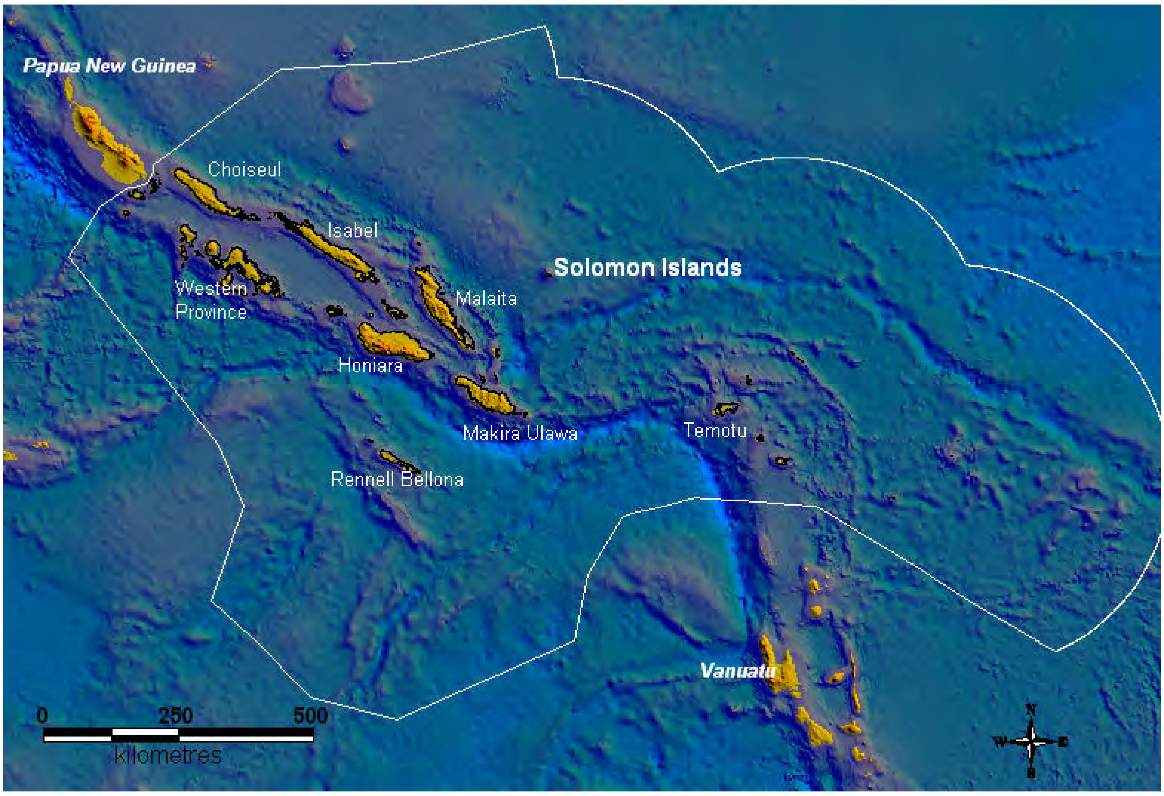

Figure 1.4: Map of the Solomon Islands.

Solomon Islands is the third-largest archipelago in the South Pacific. The main islands vary in length from 140 to 200 km, in width from 30 to 50 km, and in type from high islands to raised atolls and low lying islands, sand cays and rock outcrops. Guadalcanal is the largest island (5340 km^2), while the others range from that size down to a size of less than 1 ha (FAO 2008; Gillett 2002).

Two climate systems affect the country. These are the southeasterly trade winds that blow from May to October and the northeasterly trade monsoon winds that blow from December until March. Between April and November, the country experiences fine, sunny, calm weather. As the islands are close to the equator, air temperature does not vary much. Mean daily temperatures throughout the year range from a minimum of 23°C to a maximum of 30°C. Rainfall ranges from 3000 to 5000 mm per year. There is generally a higher rainfall in the wet (monsoon) season (SICFCS 2002; Turner 2008).

The 1999 census figures show a population of 409,042, a total population density of 13 /km^2, and an annual growth rate of 2.8%. The 1999 growth rate is a drop from the 3.5% rate for the 1976–1986 period (SPC 2008a). In terms of population distribution per province, Malaita has the highest population (122,620) and Rennell-Bellona and Temotu provinces have the lowest (2377 and 18,912, respectively). Most Solomon Islanders live near or on the coast. As rural dwellers they live a subsistence life heavily dependent on gardening, fishing and hunting (SICFCS 2002).

Solomon Islands attained self-government in 1976 and independence on 7 July 1978. With independence, a parliamentary democracy system of government was adopted. The country has a constitutional monarchy represented by a Governor-General, who is the head of state. Legislative power is vested in the national parliament, which is elected every four years.

Parliamentary democracy is based on the multi-party system. Executive authority is held by the Cabinet, led by the Prime Minister. Emphasis is placed on the devolution of power to provincial governments, and traditional chiefs and leaders have a special role within this arrangement (Cox and Morison 2004; Turner 2008). For local government, the country is divided into 10 administrative areas, of which nine are provinces administered by elected provincial assemblies, and the tenth is the town of Honiara, administered by the Honiara Town Council. The provinces are Central, Choiseul, Guadalcanal, Honiara Town, Isabel, Makira-Ulawa, Malaita, Rennell and Bellona, Temotu, and Western (Wikipedia 2008).

The bulk of the population depends on agriculture, fishing, and forestry for part of its livelihood. Most manufactured goods and petroleum products are imported. Natural resources include fish, forests, gold, bauxite, phosphates, lead, zinc, and nickel. Agriculture products include cocoa beans, coconuts, palm kernels, rice, potatoes, vegetables, fruit, timber, cattle, pigs, and fish. The main industries are fish (tuna), mining, timber, palm oil, and tourism. Approximately 75% of the labour force in 2000 worked in agriculture, 20% in services and 5% in industry. The gross domestic product (GDP) for 2000 was made up of 47% services, 42% agriculture, and 11% industry. A study by the Asian Development Bank showed that the contribution of the fishing sector to GDP in Solomon Islands was about 12.8% in 1999 (Gillett and Lightfoot 2001). In 2006, USD 256 million was spent on the import of food, plant and equipment, manufactured goods, fuels, and chemicals. Import partners for 2006 were Singapore (28.6%), Australia (26.5%), Japan (4.7%), New Zealand (4.5%), and Fiji (4.1%). In 2006, USD 237 million was acquired from the export of timber, fish, copra, palm oil, and cocoa. Export partners in 2006 were China (50.7%), South Korea (8.6%), Thailand (6.5%), and Japan (5.7%) (CIA 2008; FAO 2008).

It has been estimated that the annual value of the production from the fisheries was about USD 80 million in the late 1990s. This comprised locally-based offshore fishing (USD 69 million), subsistence fishing (USD 8 million), coastal commercial fishing (USD 2 million), and foreign-based offshore fishing (USD 1 million). More than 90% of marine product exports have usually comprised tuna and tuna-related products, primarily in frozen or canned form. Non-tuna exports have been dominated by bêche-de-mer, trochus products (including semi-processed buttons), blacklip pearl oyster and shark fins (FAO 2008; Gillett 2002).

Fisheries resources have always been an important source of dietary protein, income and employment opportunity for Solomon Islanders. Various facts have supported this assertion: fisheries being amongst the major contributors of foreign exchange earnings, the large number of people either directly or indirectly employed within the sector, and a high per capita consumption rate of 45.5 kg/person/year in 2002. The recent Central Bank of Solomon Islands' report highlighted fisheries as one of the sectors that provide hope for the economic recovery of Solomon Islands (DFMR 2005a; Skewes 1990).

1.3.2 The fisheries sector

The fisheries sector can be classified into three broad categories: oceanic, coastal and freshwater fisheries. The oceanic fishery is characterised by industrial-scale commercial operations targeting large pelagics such as yellowfin, skipjack and bigeye tuna in the country's territorial waters and EEZ. The coastal fisheries closer inshore target stocks of small pelagics, reef fish, crustaceans, echinoderms, molluscs and occasionally large pelagics. Fresh-water fisheries target fresh-water species of gobies, prawns, eels, mullets and perches.

By comparison, the fresh-water fishery is small and accounts for only a small portion of total production. However, it is important and represents the only fishery in many remote inland parts of the country.

About 90% of the Solomon Islands population lives in rural areas, so subsistence and artisanal fishing activities are widespread and of great importance. These fisheries are concentrated on coastal and nearshore reefs and lagoons. The target resources are reef-associated finfish, bêche-de-mer, trochus, giant clam, lobster, and turbot (FAO 2008). Since the 1800s, traders have purchased large amounts of bêche-de-mer, turtle shell, pearl shell, trochus and green snail from Solomon Islands (Cook 1988). Exports of most of these resources continue today.

Offshore tuna fishery

Tuna is an important export commodity, ranking among the country's top three exports. The tuna industry is made up of the domestic industrial surface tuna fishery with on-shore processing, a foreign-based fleet of the distant water fishing nations (DWFN) longlining for both tuna and sharks, and small-scale, domestic tuna operations.

Industrial surface tuna fishery and onshore processing

The Taiyo Fishing Company of Japan conducted exploratory fishing surveys for skipjack tuna in 1970 and 1971. These trials were very successful, resulting in a pole-and-line fishery being established in Solomon Islands in 1971 (Argue and Kearney 1982). A joint venture was then signed between the Government of Solomon Islands and Taiyo GKK (Gyogyo Kabushkiki Kaisha), a major Japanese firm, in 1972, forming Solomon Taiyo Limited (STL), a Solomon Islands registered fishing company. The company then established a fishing base at Tulagi with freezing, cold storage, canning and smoking facilities (Argue and Kearney 1982; Chapman 1998). A second base was established in Noro in 1976. Catches in the mid-1970s were around 7000 to 10,000 mt annually from 11–12 pole-and-line vessels (Chapman 1998).

A second domestic tuna company was established in 1977, National Fisheries Development (NFD) Limited. Both companies operated fleets of pole-and-line vessels, with NFD selling its catch to STL. In the late 1970s, vessel numbers increased to 20–23, with the annual catch also increasing to 15,000–20,000 mt (Chapman 1998). Most of the catch taken by STL and NFD was exported as frozen whole fish, as the STL's tuna cannery was small, with an annual throughput of 4200 mt (Chapman 1998). Also in the late 1970s, the Secretariat of the Pacific Community's (SPC's) Skipjack Survey and Assessment Programme conducted a tagging programme in the waters of Solomon Islands as part of its regional stock assessment work. The first cruise was conducted in November and December 1977, and 2493 skipjack and 117 yellowfin were tagged (Kearney and Lewis 1978). On the second cruise, in May and June 1980, 3728 skipjack and 741 yellowfin tuna were tagged (Argue and Kearney 1982).

In 1980, STL brought in a group purse seiner, which landed 960 mt in its first year. The number of pole-and-line vessels was also increased in the 1980s – ranging up to 35 in some years – with a few of these vessels fishing under a charter arrangement. Catches increased in the 1980s, fluctuating between 20,000 mt and 38,000 mt for the pole-and-line fleet and steady at around 5000 mt for the group purse seiners. In 1987, STL moved from its Tulagi facility to a new and larger cannery facility at Noro; the throughput of this facility was 14,000 mt annually, and another 5000 mt were processed at the arabushi smoking plant (Chapman 1998).

NFD introduced two purse seiners to the fishery in 1988, with the ownership of the company changing hands in 1990. The catch of STL and NFD fluctuated during the 1990s from 30,000 mt to 55,000 mt, although the actual total allowable catch (TAC) for the fishery was set at 120,000 mt by the Solomon Islands Government. In response to this, the government started to allocate the 120,000 mt TAC for this surface fishery to other companies as a means of encouraging further development. In 1997 there were eight companies involved in the surface tuna fishery, with most of these companies bringing in foreign vessels – mainly purse seiners – to catch the quota assigned to them by the government (Oreihaka 1998).

Unfortunately, in the late 1990s and early 2000s, social unrest in Solomon Islands greatly affected locally-based tuna fishing operations, and STL ceased operations for a while, then reopened with a reduced number of pole-and-line vessels and greatly reduced cannery throughput. In 2000, the total catch by local and foreign vessels in the surface tuna fishery in Solomon Islands was only 12,669 mt (Oreihaka 2002). As social unrest settled down, fishing operations picked up, and in 2005 the catch by both the domestic and foreign fleets was 94,924 mt (Diake 2006).

Longlining for tuna and sharks

Longlining for tuna in Solomon Islands' EEZ commenced in the mid-1970s. From 1976 to 1985, longliners working as domestic operations caught 200–800 mt annually. Also, Japanese longliners worked in Solomon Islands' EEZ under bilateral access from 1978 to 1996, with varying numbers of vessels and yearly catches fluctuating from 200 mt to 7600 mt (Chapman 1998; Oreihaka 1998). In 1995, the company Solgreen was established. This company brought in foreign-flagged tuna longliners to catch and land product in Solomon Islands for export as fresh fish to Japan. Solgreen set up a small processing area for receiving the catch and processing and packing it for export. This company also chartered a 727 aircraft to fly the fish from Honiara to Brisbane (Australia), where it was loaded on regular passenger flights to Japan (Chapman 1998).

Also in the mid-1990s, four companies were licensed to do shark longlining. In 1997, there were 13 vessels licensed for shark longlining, with another 42 longliners licensed for tuna (Oreihaka 1998). In 1998, there were three shark longliners, with 10 mt of shark landed for export as frozen trunks (Anon. 1999). The domestic tuna longline catch also dropped as a result of the social unrest, from 1197 mt in 2000 to 407 mt in 2001 (Oreihaka 2002). The longline fleet in 2001 was made up of nine shark longliners, and 27 domestic and 18 foreign tuna longliners. By 2005, the locally-based Solgreen Company was suffering financial difficulty and only had two vessels fishing (Diake 2006). The company ceased operation soon after, leaving no domestic tuna longlining operations in Solomon Islands.

Small-scale tuna fishery including fishing around FADs

Solomon Islanders do not have a history of tuna fishing, although some tuna were taken opportunistically from paddling canoes when they were close to the reef. Even when the first commercially made fibreglass canoes and skiffs were constructed in 1971, their main purpose was for transportation and fishing in sheltered waters, with some trolling (Chapman 2004;

Preston *et al.* 1998). In the first 10 years, over 1000 of these canoes and skiffs were made (Gulbrandsen and Savins 1987).

Fish aggregating devices (FADs) were first introduced to Solomon Islands in 1981, when STL deployed 30 for their pole-and-line fishing operations (Sibisopere 1999). All of the early FADs were deployed by STL or NFD. These two companies maintained around 100–150 FADs during the 1980s and 1990s. Most of the FADs were deployed well offshore, although the companies had no issue with small-scale fishers trolling around them, if they ventured offshore and located one.

Also during the 1990s, the Rural Fishing Enterprises Project (RFEP) deployed several FADs to assist local fishers at the locations where they had established fish bases. The tuna caught was mainly for bait for their bottom fishing activities, although some was also sold for eating (Preston *et al.* 1998). Unlike in most other Pacific Island countries and territories, the Solomon Islands Fisheries Department has never been involved in a FAD programme for small-scale fishers (Chapman 2004).

In the 2000s, a group of Honiara-based fishers uses outboard-powered fibreglass canoes to target tuna around FADs off the west coast of Guadalcanal that have been deployed by STL and NFD. These operators provide a significant source of fresh yellowfin and skipjack tuna to the market in Honiara on a daily basis (Ferral Lasi pers. com. April 2008).

There are a small number of charter vessels located at Gizo and Honiara that have been operating since the 1990s, with the main focus on blue-water gamefishing. The gamefishing club in Honiara holds two tournaments each year, with a range of privately-owned motorised canoes and sports fishing craft taking part (Whitelaw 2001).

Deep-water snapper

Deep-water snapper fishing was introduced to Solomon Islands (Gizo) in 1977/1978 by SPC, when fishing trials were undertaken and local fishers trained in deep-water snapper fishing gear and methods (Eginton and James 1979). Following the trials and training, government fisheries officers conducted surveys from 1978 to 1982 with good catches of eteline snappers (Adams and Chapman 2004; Dalzell and Preston 1992; Wata 1988). A Japanese-led survey in 1985 recorded good catches of some deep-water snapper species at different locations around Solomon Islands (Wata 1985; 1988).

Many donors have been involved with setting up rural fishing stations in an attempt to generate income in rural areas. The primary focus of these centres has been to encourage fishers to target deep-water snappers for both export and marketing in Honiara. Over the years there have been up to 27 rural fishing centres established around Solomon Islands; many have been rehabilitated after original equipment had failed. One such project was the European Union (EU)-sponsored RFEP, which supports rural fishers in both production and marketing. The project has fostered the establishment of fishing groups based at new or existing fisheries centres, some of which it has rehabilitated and re-equipped, and has provided training in catch handling and specialised fishing skills for deep-water snappers, as well as marketing assistance (Preston *et al.* 1998). As a result of project activities, deep-bottom fish landings rose in the 1990s to over 170 mt in 1996 and 1997 (FAO 2008; Gillett 2002).

Unfortunately, once the donors turned the rural fishing centres over to the provinces to operate, many failed due to lack of maintenance of equipment and the fact that they were not economically viable to operate. With limited stocks and the high cost of operating the boats, fishers were not enthusiastic about the operation (Kile undated). In the early 2000s, annual catches of deep-water snapper dropped significantly. SPC was asked to provide technical assistance to four existing centres in 2003 and in response offered additional training in gear and fishing methodology (Sokimi and Chapman 2004). The deep-water snapper fishery continues today, mainly in an opportunistic manner when fishers choose to fish for these species.

Aquaculture and mariculture

Aquaculture is not a traditional practice, as the highly productive reefs of the country have historically provided a ready source of food. Although there have been previous introductions of various tilapia species, these were never managed in any way. However, development of a cash economy in the country has stimulated interest in the culture of commercially valuable species (Nichols 1985). The government has had varied success with its aquaculture programme. Many of the projects have been established to replenish declining stocks.

Since the 1980s, and with the assistance of the International Center for Living Aquatic Resources and Management (ICLARM – now called WorldFish Center), prawns, pearl oysters, giant clams, trochus, green snail, corals and seaweed have been farmed. ICLARM had a large hatchery at Aruligo on the north coast of Guadalcanal and several grow-out facilities, notably Nuse Tupe in Western Province and Marau Sound. A large proportion of ICLARM's research in the Marau Sound centred on giant clam and sea cucumbers. Marau Sound was also a supplier of cultured corals (*Scleractinia* and *Alcyonacea* spp.) to the overseas aquarium trade (Kinch 2004).

Prawns

Initial efforts were aimed at producing freshwater prawns (*Macrobrachium rosenbergii*) using post-larvae purchased from Tahiti. Production was not high, reaching only 920 kg/ha/year. After two disappointing seasons in 1986 and 1987, and following a dispute over ownership of land, production of freshwater prawns ceased (Delaune 1989). In 1986, the company started mariculture plans for saltwater prawns *Penaeus monodon*. Production was over 5 mt in 1988, most of this being sold on the local market, but production figures were low, averaging 750 kg/ha/yr. This was attributed to poor pond management and technique used, as well as poor-quality food (Delaune 1989). A hatchery supplied post-larvae for stocking the ponds, but poor training led to cessation of the hatchery. A feasibility study concluded that there was not enough gravid *P. monodon* to supply the hatchery. By the mid-1990s, two commercial prawn farms were producing the giant tiger prawn (*Penaeus monodon*). Production of about 20–30 mt per annum was achieved. The farms were closed as a result of local ethnic tension (SPC 2008).

Tilapia

Oreochromis mossambicus was introduced to Solomon Islands in 1957 for stocking into natural lakes and ponds. In 1970, large-sized tilapia were reported from Lake Te Nganno on Rennell Island. Tilapia had spread throughout most freshwater ponds in the country but was not readily accepted by the people. Attempts at cultivating it in ponds did not materialise. A few subsistence farms of *O. mossambicus* are found. The government has considered the possibility of introducing a higher-value, faster-growing species such as the *O. niloticus* or Nile tilapia (SPC 2008).

Coral

The wild collection of corals has brought substantial income to rural communities in many provinces. Wild-coral harvesting caters to three main markets: the local trade (as a source of lime for chewing with betelnut), the curio trade (dead corals), and the marine aquarium trade (live corals) (Teitelbaum 2007a).

Aquarium trade exports from Solomon Islands currently account for around 4% of the international coral trade. The main coral supply areas are the Nggela Islands, with smaller amounts supplied from the Marau Sound, and in and around the capital, Honiara. The free-on-board (FOB) price for corals exported from Solomon Islands is around USD 3 or SBD 22 per piece. Retail prices for corals on the international market range from USD 35 (SBD 266.70) to USD 130 (SBD 990.55) per piece, depending on species, quality and rarity (Lal and Kinch 2005).

Teitelbaum (2007b) writes that the Marine Aquarium Council (MAC) is drafting a Mariculture Area Management Plan. Management plans are established within local communities that are involved in the aquaculture of clams and corals within Western Province. The goal is to obtain MAC certification of the products. So far, regulations on coral harvesting in Solomon Islands are basic but a licence is required for exporting corals overseas. He believes the introduction of quotas on wild-caught fragments would help in promoting farming activities.

Seaweed

Kappaphycus seaweed (*Eucheuma*) farming has been trialled in the past with variable results in Solomon Islands. Trials were carried out from 1988 to 1991 mainly in Western Province. High growth rates were seen but trial plants were destroyed by the herbivorous fish of the *Siganidae* species. On Rarumana in Western Province the plants survived, enabling farming to semi-commercial levels with about 3 mt purchased from September to December (Rural Fishing Enterprise Project 2002). There were four operational farms in 1990. A national campaign to rejuvenate seaweed farming in the rural areas is underway. Extension and development work is being carried out through the Department of Fisheries and Marine Resources (DFMR) with the support of provincial fisheries departments and the EU. The objective of the campaign is to have at least 500 farmers producing 80 mt of dried product per month. The two main target sites for production are North Malaita and Gizo provinces. After just eighteen months the country has already achieved a production rate of 200 mt per annum (SPC 2008).

Reef and reef fisheries (finfish and invertebrates)

Coral-reef habitat

A Rapid Ecological Assessment (REA) undertaken by The Nature Conservancy (TNC) in 2004 showed that the marine biodiversity of Solomon Islands was exceptionally high. The survey found 80% of seagrass representatives reported from the Indo-Pacific region, extraordinarily high coral diversity (790 species of corals) and rich concentrations of reef fishes (1019 species). As a result of this survey, Solomon Islands is now recognised by the scientific community as part of the global centre for marine diversity known as the 'coral triangle' (Green *et al.* 2006).

Finfish

The coral-reef finfish fishery is the main provider of food for the majority of the population. The Asian Development Bank estimated in 1997 that the national subsistence catch exceeded 13,200 tonnes annually and was likely to increase in line with population growth (ADB 1998). The total coral-reef fish fauna consists of 1019 species representing 82 families and 348 genera (Green *et al.* 2006). Of these 82 families, 20 are considered food fish families. Out of the 20 families, five feature prominently in local catches and therefore are considered most important. In decreasing order these are: snappers (Lutjanidae), surgeon fish (Acanthuridae), parrotfish (Scaridae), groupers (Serranidae) and emperor fish (Lethrinidae). The production estimate for reef fish is unavailable as no dedicated studies have been performed to address this question. Sulu *et al.* (2000) estimated that annual production by subsistence and artisanal fisheries amounts to 10,000–14,000 mt annually with a nominal value of USD 8–9 million. This fishery's independent estimate includes coastal pelagics and other non-reef fishes, which implies that less than 10,000 tonnes of reef fish are harvested annually.

An increasing number of reef fish are caught by artisanal and commercial fishers who sell their catches in the urban centres. Honiara provides the biggest market for reef fish in the country. No reliable or comprehensive data are available for reef fish landed and sold in Honiara. The fishing techniques commonly employed to exploit reef fish are handlining, spearfishing and gillnetting. Trolling is used to catch pelagics such as tuna, barracuda, rainbow runner, and Spanish mackerels. According to Skewes (1990), there was no national legislation on reef fish in 1990. In general, policies in Solomon Islands are to reserve reef fish resources for the local reef owners to manage.

Sharks

An inspection of the catch of a shark longliner in 1984 found 62% of the catch was made up of *Carcharhinus spallanzani*. Previously there have been several commercial-scale shark fishing operations but they have generally been of a short duration. Skewes (1990) noted one venture targeting deep-water species primarily for the production of shark liver oil. Only the fins are used commercially, although on occasion the skin, meat and oil are also used, and the meat of sharks caught by subsistence fishers is usually eaten. No stock assessment work has been carried out on sharks. It is considered that the resource is not under any significant pressure.

Live-reef fish fishery

Since 1994 various companies have operated collecting live reef food fish. The important target species are the square-tailed coral trout (*Plectropomus areolatus*), camouflage grouper (*Epinephelus polyphekadion*) and the flowery grouper (*E. fuscoguttatus*) (FAO 2008; Gillett 2002). The lucrative live-fish export market places considerable pressure on inshore resources as the short-term gains afford villagers financial relief. There is an absence of alternative sources of income in many coastal villages and the live reef food fish trade

(LRFFT) is, potentially, a means to provide steady income. The main market is Hong Kong. The prices paid by IKA Holdings Ltd from 1994 to 1996 ranged from SBD 3.50/kg to SBD 5.50/kg, plus an additional 50 cents per kg that the company paid to a community fund (Lausu'u 2006).

From 1997–2000, the WorldFish Center conducted research to investigate the feasibility of collection and culture of pre-settlement larvae of reef fish targeted for the LRFFT (Hair and Doherty 2003). The study was conducted in Gizo, Western Province and Ontong Java in Malaita. In 1998, a coral-reef fish biodiversity survey was conducted in Santa Cruz, Temotu Province. Seven hundred and twenty-five species, including many previously unreported ones, were found during the study. In 1998, various aspects of the LRFFT were studied through another ACIAR-funded project at three locations in the country: Roviana Lagoon, Marovo Lagoon and Ontong Java. This study focused on the biology of the LRFFT species and the socioeconomic and management aspects of the fishery (Donnelly *et al.* 2000). Hamilton (2004) also covered aspects of the LRFFT when doing PhD studies on bumphead parrotfish in Roviana Lagoon, Western Province.

In 1997, the Fisheries Department realised the need to develop a strategy for sustainable management of the fishery. ACIAR was asked to formulate a management plan and in February 1999 a moratorium was imposed on all new live-fish export licenses. Fishing during spawning aggregations was the catalyst for immediate action to develop a management strategy for the trade. In November 2000 the moratorium was lifted and in March 2001 three live-fish export licences were issued for a one-year operation, although none of the licence holders were active. As of March 2005, no licence had been issued and there were no active operations. The current management provides for the licensing of operators (Lausu'u 2006).

Aquarium fishery

The marine aquarium industry involves the collection, selling/purchasing, packing and exporting of commodities for aquaria (Lam 2003). The export of marine ornamentals began in 1994 with two companies that supplied the US market. From 2000–2004 these companies exported 427,170 pieces of aquarium fish valued at USD 1250,400 (DFMR 2005b). One other company was established a few years later to export dead coral and live rock. The aquarium dealers in the country obtained their supplies exclusively from collectors in Gela, Marau, and Western Province. More than 75% of the aquarium fish and corals exported are taken from reefs in Gela, Central Island Province. One hundred different aquarium fish species are targeted, including: clown fish, tangs, gobies, damsels, wrasses, blennies, angelfish, triggerfish, puffers and eels. In addition, invertebrates, corals and live rocks also form part of the regular exports. In the period 2000–2004, 245,000 pieces of live coral valued at USD 72,000 were exported, while 3000 shrimps valued at USD 2800 were exported from 2004 to 2006 (Teitelbaum 2007b). Prior to the ethnic tension different species of giant clams cultured in Aruligo and Marau were also exported in significant quantities.

Invertebrates: bêche-de-mer (sea cucumber)

There are twenty-two known species of sea cucumber (*Holothuria atra*, *H. fuscogilva*, *H. nobilis*, *H. fuscopunctata*, *H. coluber*, *H. scabra*, *H. pervicax*, *H. edulis*, *Actinopyga mauritiana*, *A. lecanora*, *A. palauensis*, *Stichopus chloronotus*, *S. hermanni*, *S. vastus*, *S. horrens*, *Pearsonothuria graeffei*, *Bohadschia vitiensis*, *B. argus*, *B. similis*, *Thelenota rubrolineata*, *T. ananas* and *T. anax*), along with a few undescribed species that are being exploited in various provinces in Solomon Islands (Ramofafia 2005). Bêche-de-mer is an important resource for many coastal communities. It is thought that exports started as early as 1845. They were well established by the late 1870s and early 1880s when up to 90 mt of bêche-de-mer were being exported to Australia annually (Bennett 1987, cited in Kinch *et al.* 2005). It is currently a multi-million-dollar industry, and is the second most valuable marine resource, after tuna, to the national economy (Ramofafia, 2005). Total exports rose from 7.3 mt in 1981 (Skewes 1990) to a peak of 715.4 mt in 1992 (Holland 1994). In 2004, 408.7 mt were exported (Kinch *et al.* 2005).

High prices have led to a rapid decline in the resource. The current status of commercially valuable invertebrates is poorly known. There have been no thorough or comprehensive resource assessment surveys due to financial constraints. However, concerns for declining stocks led to the DFMR imposing a 2005 moratorium on harvesting sea cucumber. This ban was relaxed in April 2007 to allow victims of the 2007 tsunami to earn some income for their rehabilitation. The ban is to be re-imposed in January 2008 (Solomon Islands Broadcasting Corporation 2005; Solomon Star 2007).

A number of resource management programmes have been initiated. The ICLARM hatchery has a reseeding programme. In addition, a community in Ontong Java is practising traditional management through seasonal closures. There is a self-imposed ban on fishing for bêche-de-mer every second year. Because of the social structure of the community (essentially controlled by village chiefs), adherence is strict (Skewes 1990).

Pearl oysters

There are three commercial species of pearl oyster present: blacklip pearl oyster (*Pinctada margaritifera*), goldlip pearl oyster (*P. maxima*), and brownlip pearl oyster (*Pteria penguin*) (Sims 1993). Most mother-of-pearl (MOP) shell exported is used for the manufacture of buttons and other clothing and jewellery items. Since August 1990, one button blank factory has been operating in Honiara, and another is planned for the Gizo area (Skewes 1990).

In 1991, there were 11,476 kg of brownlip oysters harvested, and in 1993 there were 26,007 kg of blacklip and 1196 kg of goldlip oysters harvested. Due to this overexploitation, a ban on the harvest of all three species was put in place in 1994. A plan to establish pearl farms is in place, with an ICLARM/Solomon Islands Government pearl farm demonstration project seeding and harvesting about 800 specimens in 1999, giving a positive outlook for future commercial operations. In 1993, the Pearl Oyster Project began with funding assistance from ACIAR. The project was implemented by ICLARM and the Fisheries Division. The objective was to identify suitable areas in the provinces where young oyster spats could be collected. Results would determine the viability of farming pearl oysters. In addition, the project investigated various materials that could be used as spat collectors. Areas investigated in 1994 included sites in Marovo Lagoon, Marau, Gela, South Malaita and Choiseul (Fisheries Division 1994).

Stock surveys in the 1990s were carried out mainly on goldlip in Isabel Province and the Kia Passage. Although high densities of goldlip pearl oyster shell were found in the Kia Passage, there were low numbers of shell suitable for culture, which meant that the Kia Passage could not support a pearl culture operation (Skewes 1990).

Giant clams

Six species of giant clam are found in Solomon Islands. These are the giant clam (*Tridacna maxima*), smooth giant clam (*T. derasa*), fluted giant clam (*T. squamosa*), rugose giant clam (*T. maxima*), boring clam (*T. crocea*) and horse-hoof clam (*Hippopus hippopus*) (Govan 1988). Except in Seventh Day Adventist (SDA) communities, clams are a widely eaten and often highly esteemed food throughout the country. Tridacnidae shells are carved for ornamental jewellery and traditional artifacts and are used for various utensils, including stock feeding troughs (Skewes 1990). In almost all the reefs throughout the country, clam populations are under pressure from sustained fishing efforts. The biggest species – *T. gigas* – is becoming very rare and is in danger of becoming extinct. Clam valves (shells) were exported in the past (1960s and 1970s), which led to local decimation of stocks in places such as Marau. In the 1980s, Taiwanese vessels poached the remote Indispensable and Roncador reefs, wiping out the entire *T. gigas* stock found there.

The ICLARM clam hatchery had grow-outs at Nusatupe in Western Province and Marau Sound in Guadalcanal. The six species of clam have been cultured in community-based farming operations (Bell *et al.* 1997; Foyle *et al.* 1997). ICLARM supplied juvenile clams to a number of reef owners to restock their reefs and for outgrowing (Fisheries Division 1994). Unfortunately, the Aruligo hatchery was destroyed during ethnic tension. This greatly reduced the number of cultured clams available for village farming and subsequent sale to the international market (Kinch 2004).

The sale and export of wild giant clams is illegal because they are protected under the Convention on International Trade in Endangered Species (CITES) and local fisheries legislation. All commercial fishing requires a licence issued by the Fisheries Division (Skewes 1990).

Trochus

Like bêche-de-mer, trochus (*Trochus niloticus*) is an important resource for rural communities because it is renewable, non-perishable and easy to harvest. Apart from the value of the shell, trochus meat is a popular local food item. In the 1950s, prior to establishment of the commercial tuna industry, trochus was the second greatest source of revenue for the country after copra. The earliest trochus export data shows that 717 mt, worth a nominal USD 100,000, were exported in 1954 (Van Pel 1956). From 1972 to 1979, the average annual export volume was 415 mt. From 1980 to 1989, annual production averaged 440 mt, rising in 1986 to 660 mt. The average production for 1990–1999 saw a sharp drop to 104 mt. This falling trend continued for 2000–2003, when production averaged 90 mt annually. The drop in production in the 1990s and 2000s occurred at a time when the trochus price was very high. The slump in production could therefore have been due to depletion in stocks. A trochus stock assessment survey conducted in the Gizo-Rarumana areas in the early 1990s by SPC revealed that stocks were already in a poor state (Adams *et al.* 1992). Stock assessment studies around Gela reefs in the mid-1990s reveal similar findings regarding the poor status of trochus resources (Foale 1996). Skewes (1990) refers to legislation that states that fishers may not catch or retain, sell or expose for sale, buy or export any trochus shell under 2.5 inches (70 mm) in basal diameter.

The DFMR has collaborated with the Overseas Fishery Cooperation Foundation (OFCF) of Japan in carrying out surveys and studies on trochus to assess the feasibility of culturing these animals. The objective is to use aquaculture to assist in restocking reef areas where stocks have been depleted (SPC 2008).

Green snails

Green snails (*Turbo marmoratus*) are relatively large marine gastropods attaining a wet weight of up to 2 kg in size (Yamaguchi 1988). The snail is fished by local small-scale artisanal fishermen and sold to traders for export. Its nacreous shell is highly prized for inlay material for lacquer ware, furniture and jewellery, while the flesh is desired by the locals as food. The resource was once an export commodity; from 1953 to 1955, 57, 78 and 84 mt, worth a nominal AUD 12,400, AUD 14,500 and AUD 19,000, respectively, were exported (Van Pel 1956). From 1972 to 1979, an average of 25 mt was exported annually (Yamaguchi 1988). Average annual production for 1980–1988 further declined to 7 mt. The last export was in 1991, when 2 mt were exported. On many reefs where the species once thrived (Marau, Marovo, Rarumana, Kia, Suavanao), it is now considered locally extinct. The OFCF (under the Solomon Islands Atoll Project) promoted restocking of the green snail resource. In 1999, this programme was very successful in mass rearing green snails for restocking. However, the programme was terminated during the ethnic crisis of 2000.

Other molluscs

A wide range of other molluscs is eaten, sold as souvenirs, or used for cultural purposes. Some commonly eaten species of shells forming part of the subsistence catch include: *Strombus luhuanus*, *Thais* sp., *Vasum* sp., *Batista violacea*, *Tectus pyramis*, *Anadara scapha*, *Anadara antiquata*, *Gafrarium tumidum*, *Turbo setosus*, *Turbo argyrostomus*, *Turbo chrysostomus*, *Acanthozostera gemmata, Octopus* sp. and others. The species *Chama pacifica*, *Beguina semiorbiculata*, *Anadara granosa* and *Atrina vexillum* are the chief raw material used in the manufacture of necklaces for Malaitan and Guadalcanal shell money. Traditional currencies are still valid in parts of these provinces to settle disputes, acquire land rights and legitimise marriages. Other species of cowries (*Cypraea* spp.) and gastropods (*Conus* spp.) are sold as souvenirs to tourists (Skewes 1990).

Lobsters

Four species of spiny lobster (*Panulirus penicillatus*, *P. versicolor*, *P. ornatus* and *P. femoristriga*) and the slipper lobster *Parribacus caledonicus* are present in Solomon Islands (Prescott 1988). Lobsters are exploited mainly in the subsistence fishery as incidental catch. Increasing volumes are now also being sold in hotels in Honiara. No proper documentation has been made on the volume of lobster being sold annually in Honiara. Prescott (1988) estimated that it is possible to achieve a production of 5 mt of lobster per year from productive areas in the country. This, he surmised, should be sufficient to sustain a small, well-managed commercial fishery. However, poor transportation and high freight costs would make such an operation risky and less profitable. As with other marine resources, lobster resources in most parts of the country are over-fished. Despite harvest size restrictions (8 cm carapace length), this commercial species has already been overexploited, with 22,894 kg exported in 1995 (Kile undated). Legislation bans the harvest, sale, purchase, or export of *Panulirus* lobster under a total length of 25 cm (Skewes 1990).

Mud crabs

The mud crab (*Scylla serrata*) is found in Northern Isabel, Western Province (Marovo, New Georgia), parts of Choiseul and Southern Malaita. Mud crabs from Maramasike in South Malaita are often sold at the main market in Honiara. Maramasike has one of the most intact mangrove forests in the country, which serves as a good habitat for this species. Little information is available on their stocks and yield potential (Skewes 1990).

Coconut crabs

Although the coconut crab (*Birgus latro*) is strictly a land invertebrate, it is often regarded as a marine resource because of its dependence in its larval stage on the marine environment. This resource is mostly used at the subsistence level and seldom sold at the market. Occasionally, supplies originating from the Russels, Reef Islands, Marovo and Isabel are sold to hotels in Honiara. Limited numbers are exported through local traders to major seafood centres, such as Hong Kong. No stock assessment work on coconut crabs has been done. However, exporters of the crabs have to apply for an annual permit (Skewes 1990).

Turtles

Five species of turtle have been identified in Solomon Islands: the hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*) loggerhead turtle (*Caretta caretta*) and olive ridley turtle (*Lepidochelys olivaceus*) (Vaughan 1980). The most harvested species are *E. imbricata* and, to a lesser extent, *C. mydas*. *D. coriacea* is seldom harvested due to its large size, which makes capture difficult. Turtles have been used for food at a subsistence level for many generations. Over the years, they have been increasingly hunted for their shell. While the green turtle is the main species used for food, the hawksbill turtle is targeted for its shell as well as for food, and their eggs are harvested for subsistence purposes (Skewes 1990).

Since November 1975, the Fisheries Division has supported a turtle programme aimed at stock management and collection of biological data (James 1977). Most work has been done on the hawksbill turtle, and a sanctuary has been declared on a group of islands forming a major nesting centre. Three thousand hawksbill turtles were exported in 1989. The extent of turtle populations in Solomon Islands is not accurately known (Skewes 1990). However, the need to protect the turtles led to the establishment of the Arnavon Management Conservation Area (AMCA) in 1995. A new regulation enacted in 1998 protects turtles during the peak nesting periods of June to August and November to January. Locals can only eat turtles from February to May and during September and October (Kile undated). Skewes (1990) writes that no individual may sell or expose for sale any turtle or part of a turtle of less than 75 cm in carapace length. This regulation does not apply to any turtle reared on a licensed farm. It is an offence to fish for leatherback turtle or to take, destroy, possess, sell or expose for sale, buy or export their eggs. Since March 1989, buyers of turtle shell have been required to keep the shells intact until they are inspected by a fisheries officer and the plates are stamped.

Turtle farms were established in the Manning Strait area to investigate population dynamics. Green turtles and hawksbill turtles were stocked into ponds. Their growth was studied and some hatchlings were released into the wild while a village community cultured others. Hatchlings were also kept for a turtle headstart project (SPC 2008).

Dugongs

Dugongs (*Dugong dugon*) are found in lagoonal or sheltered areas with sea grass beds. Though they are associated with sea grasses, they feed specifically on the smaller and inconspicuous species *Halophila ovalis*. Dugongs are traditionally eaten in North Malaita, Gela and Isabel, where numbers are relatively high compared to other parts of the country. Specimens are also recorded from Aruligo, Guadalcanal and Uepi in Marovo. Detailed information on stock level and distribution across the country is not available (Skewes 1990).

Crocodiles

The saltwater crocodile (*Crocodilus porosus*) is found in small numbers. Throughout the 1970s and 1980s they were hunted for their skins, which were exported to Europe to be made into high-quality bags and fashionable accessories. Harvesting of crocodiles was banned in 1989 after a country-wide study by Sydney University found that the populations were being severely depleted from over-fishing (Messel and King 1990). Crocodile numbers have now increased significantly after the moratorium of more than 17 years. Due to the increase in attacks on domestic animals by crocodiles, the Conservation Department and the Fisheries Division have conducted surveys to decide whether to reopen the market. Interest in crocodile farming has been expressed. Crocodile farming was initiated and in 1983 several small-scale farms were in operation, funded by interests from PNG (SPC 2008). There is legislation banning the export of crocodiles and their skin or products. There is also legislation enforcing a ban on the sale of any crocodile or crocodile skin with a belly-width of less than 50 cm (Skewes 1990).

Ciguatera

In 1992, ciguatera fish poisoning was not considered a major health problem. There was no organised research or monitoring of ciguatera fish poisoning carried out to determine the status of the problem. Although there were no confirmed cases of ciguatera fish poisoning, traditional knowledge and anecdotal information showed that cases were restricted to reefs, atolls and small islands. The fish species considered ciguatoxic are: *Lutjanus bohar*, *Lutjanus sebae*, *Sphyraena barracuda*, *Symphorichthys spirilus* (or *Symphorus nematophorus*), and *Platax teira*. It is believed that some people use traditional medicine for treating ciguatoxin-intoxicated patients. Apart from the regulation imposed by the provincial government of Temotu Province prohibiting the sale of fish species considered ciguatoxic in the province, there is no law or regulation concerning ciguatera poisoning (Oreihaka 1992).

1.3.3 Fisheries research activities

The Research and Resources Management Section provides technical and scientific advice to government on all aspects of subsistence, artisanal and commercial fisheries development and management, and has responsibility in these matters for both domestic and foreign fishing. The section undertakes resource assessment surveys relevant to the monitoring of exploited stocks (Fisheries Division 1994). Due to limited equipment, facilities and human resources, the section cannot conduct independent scientific research. As such, it continues to rely on the assistance of external agencies and partner organisations for conducting other sophisticated and large-scale research activities.

Prior to its closure in early 2000, the ICLARM Coastal Aquaculture Centre (CAC) carried out a number of research projects, most in collaboration with the Fisheries Division. These included: the development of village-based support to giant clam farms, collection of blacklip pearl oyster spat to support pearl culture, and the experimental culture of bêche-de-mer. The Arnavon Islands located between Isabel and Choiseul Islands are host to a number of marine research projects, including those sponsored by TNC, the World Wildlife Fund for Nature (WWF), the Biodiversity Conservation Network, ACIAR, ICLARM, the South Pacific Regional Environment Programme (SPREP), and the Great Barrier Reef Marine Park Authority. Many of the projects involve biodiversity conservation, turtle protection, and the effects of a marine reserve on species abundance. Research into green snail and trochus has also been conducted with the assistance of Japan's OFCF, concentrating on areas in the Russell Islands and Central Province (FAO 2008). As noted earlier, the Japanese led a 1985 study on the composition and diversity of deep-bottom fish species in selected parts of the country (Wata 1988). The most recent study of significance to be conducted in the country was the REA work undertaken by TNC in 2004 (Green *et al.* 2006).

Current research activities

The DFMR, in collaboration with the WorldFish Center, has completed a survey of brownlip and blacklip oyster resources in parts of the country. The department is planning to carry out a stock assessment of crocodile and dolphin resources. The WorldFish Center is also involved in a sea cucumber management project in Kia, Isabel Province. The management initiative is aimed at relieving fishing pressure by creating alternative sources of income and closely working with the communities concerned in developing a fisheries management plan. The centre is currently involved with WWF in assessing coral-reef damage caused by the March 2007 tsunami in Western Province. There are other organisations involved in community-based work and this is outlined in the next section on fisheries management.

1.3.4 Fisheries management

The Department of Fisheries and Marine Resources operates under the *Fisheries Act 1998*, which provides the legal framework for fisheries management and development in Solomon Islands (DFMR 2005a). The department is structured in five sections: the Research and Resources Management Section; the Licensing, Surveillance and Enforcement Section; the Provincial Development and Extension Services Section; the Aquaculture Section; and the Statistics and Information Section. The various provincial governments also have their own fisheries departments or officers, who are variously engaged in fishery extension, development, research and monitoring work in conjunction with the national Ministry of Fisheries and Marine Resources (FAO 2008; Gillett 2002).

The main fisheries law is the *Fisheries Act of 1998*, which, along with the various fishery regulations under the Act, establishes rules for both domestic and foreign fishing of all kinds. Other relevant legislation includes the *Fishery Limits Act (1997)* and the *Delimitation of Marine Waters Act (1988)*, under which Solomon Islands lays claim to a 200-mile EEZ and defines the various fishery zones included therein (FAO 2008). Other legal documents of relevance to fisheries are the *United States of America Treaty Act*, and the *Continental Shelf Act* (DFMR 2005a).

In 1995, Diake wrote that several regulations and amendments have been introduced over the years to conserve and manage marine resources. These regulations were mainly on size control for crayfish (of the genus *Panulirus)*, trochus shell (*Trochus niloticus*), coconut crab (*Birgus latro*), saltwater crocodile (*Crocodilus porosus*) and for turtles other than the leatherback turtle (*Dermochelys coriacea*). A total ban on the harvesting of leatherback turtles is currently in force. The regulations on other turtles and crocodiles have also been amended recently and a total ban on the trade of these resources is in effect. Provisions for the establishment of coral and coral-sand reserves fall under the *1972 Fisheries Act*. No regulation has been created to protect the other inshore resources presently exploited for trade purposes, but Diake believes this will be produced once the required scientific information is available (Diake 1995).

About 80–85% of the land and marine resources are subject to customary ownership by family groups or clans. Tribal property rights usually extend from the inland forest to the outer extremity of the reef. In Solomon Islands, Customary Marine Tenure (CMT) forms part of the framework that regulates social and political relationships and defines cultural identities. The land and marine tenure system dictates that family groups or clans legally have strong rights to ownership of, and decision making for, their forest and inshore marine resources. Their livelihood is dependent on the continued existence of these resources. CMT is recognised under the Solomon Islands Constitution (SICFCS 2002).

Acknowledging the importance of community ownership of marine resources, programmes have focused on community-based management. With reference to heavily depleted stocks of trochus, bêche-de-mer and green snail in Western Province, Adams *et al.* (1992) recommended strengthening and encouragement of traditional systems, with communities taking ownership of resource management supported by government. Various non-government organisations work with local people. WWF is currently working with grass-roots organisations from communities around Western Province, including Ranogga, Kolombangara, Vella La Vella, Tetepare, Gizo and Marovo, in promoting community-based management programmes. Other projects currently undertaken by the organisation involve working with communities in Sasakolo, Isabel, Ranogga, and Tetepare to protect critical nesting beaches used by the leatherback turtle *Dermochelys coriacea*. WWF also serves as the node for the ongoing Global Coastal Reef Monitoring Network (GCRMN) in the country. Several permanent transects are set up in a number of sites in Western Province. The 2007 tsunami has adversely affected many of its project sites. A joint assessment with WorldFish Center after the tsunami revealed that some of the coral reefs in the conservation sites in Ranogga have been raised above sea level.

The Foundation of the Peoples of the South Pacific International (FSPI) has the goal of making coastal communities become self-reliant through sustainable resource management. In Solomon Islands, FSPI is closely involved with coastal communities in the promotion and establishment of marine protected areas. FSPI has ongoing programmes in Langa Langa (3 sites), Gela (6 sites) and Marau (5 sites). Two new sites are planned for Malu'u, Malaita.

TNC is another key partner organisation with an office in the country. Currently it is working with the landowners in setting up a marine protected area in Chivoko, Choiseul. TNC has also continued to work with the landowners of Kia and Posarae in the management of the Arnavon Island conservation area, ensuring that the largest turtle rookery on the island is left undisturbed. TNC is currently involved in building partnerships with landowners of Sasakolo, Isabel Province to set up a marine resources conservation area that will also preserve leatherback nesting sites in the area.

Kile (undated) states that community-based management of coastal resources in Solomon Islands is the *de facto* inshore management regime as village communities have ancestral-based customary tenure rights for 88% of nearshore waters.

1.4 Selection of sites in the Solomon Islands

Four PROCFish/C (Pacific Regional Oceanic and Coastal Fisheries – coastal component) sites were selected in Solomon Islands: one at Marau in Guadalcanal Province, one at Sandfly Island, Nggela Island in Central Province, and the other two in Western Province: Rarumana on Parara Island and Chubikopi on Marovo Island (Figure 1.5). These sites were selected as they shared most of the required characteristics for our study: they had active reef fisheries, were representative of the country, were relatively closed systems,[7] were appropriate in size, possessed diverse habitats, presented no major logistical limitations that would make fieldwork unfeasible, had been investigated by previous studies, and presented particular interest for the Solomon Islands Fisheries Department and the provincial governments.

Figure 1.5: Map of the four PROCFish/C sites selected in Solomon Islands.

[7] A fishery system is considered 'closed' when only the people of a given site fish in a well-identified fishing ground.

2. PROFILE AND RESULTS FOR NGGELA

2.1 Site characteristics

Nggela Island is located in Central Province (Figure 2.1). Sandfly Island is located on the Western end of the main island of Nggela being separated by the narrow Sandfly passage. Our survey work was focused on the western part of Sandfly, which includes Olevugha, Semege, Niumala, Mangalonga, Ravusodukosi and surrounding islets. The island/islets surveyed tend to have a crenulated coastline, a legacy of its geological past. There is an absence of large mangrove forest except for small, isolated patches surrounding semi-enclosed bays. There is strong water exchange through the islands, resulting in high oceanic influence and permanent presence of clear waters. Reef flats in Sandfly tend to be narrow in width. Big outbreaks of crown-of-thorns starfish were seen on some reefs. Fishers reported that infestation has been ongoing for some time. A significant area on the affected reefs has been bleached or degraded.

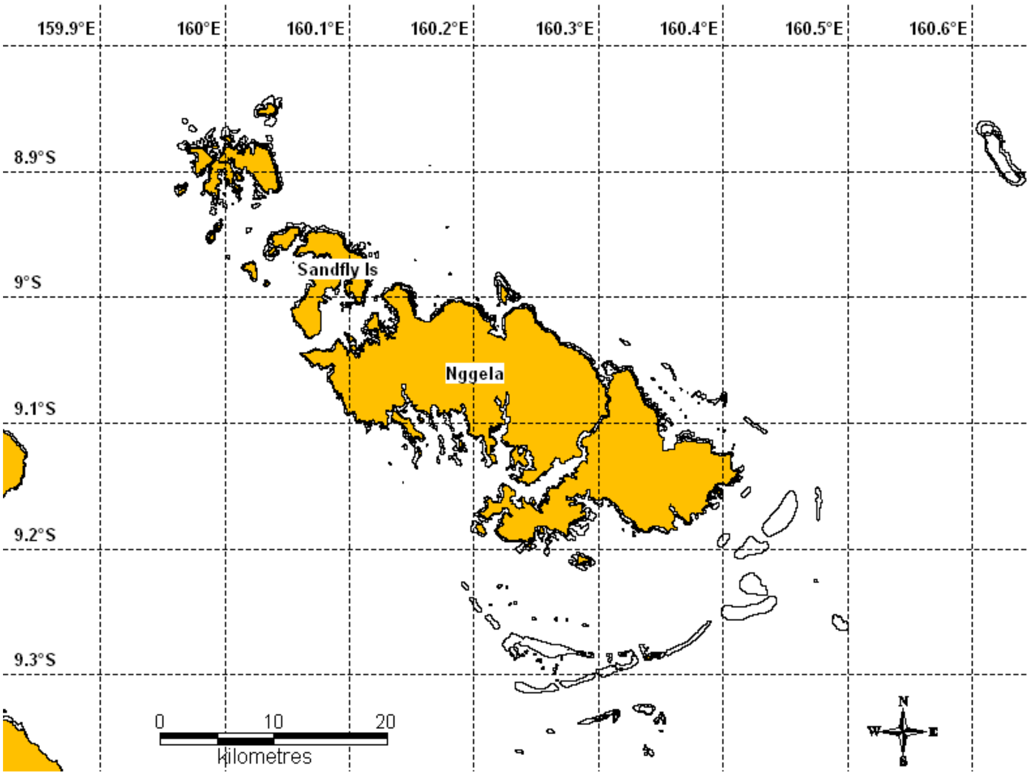

Figure 2.1: Map of Nggela.

2.2 Socioeconomic surveys: Nggela

Socioeconomic fieldwork was carried out in the Nggela community on Sandfly Island located in the Central Island Province of Solomon Islands from 14 to 21 June 2006. The community consists of a number of smaller villages, which all share the same fishing grounds. Nggela community is one of the most regular suppliers of seafood to the Honiara market. Also, Nggela fishers are heavily engaged in supplying live coral for the aquarium trade. In addition, Nggela has a small tourist resort that offers employment to a number of local people.

The survey included four smaller villages and results are referred to as 'Nggela' in the following. The total population amounts to 1891 people. The survey included 49 households, i.e. 17.5% of the total number of households (280), with 28 interviews in Leitoga, 5 in New Mala, 13 in Olevuga and 3 in Salavo. All (100 %) of the surveyed households are engaged in some form of fishing activities. In addition, a total of 36 finfish fishers (26 males and 10 females) and 88 invertebrate fishers (46 males and 42 females) were interviewed. The average household size is 6 people; however, the range observed among the four villages was 4–10 people per household. Household interviews focused on the collection of general demographic, socioeconomic and consumption data.

Because of Nggela's proximity to the Honiara market, and possible, although not yet easy, transportation access, a lot of marketing opportunities for seafood are available and used. Prices that are paid for live and dead coral depending on size, quality and species by Honiara-based aquarium trade agents are on average about SBD 4.02 /piece. Wild harvest is attractive for Nggela fishers and they may obtain a net revenue of SBD 5362 /year (gross revenue = SBD 6580 /year). Survey results suggest that about 200 villagers are involved in the collection of aquarium organisms and ~30–40 supply corals.

Seafood, in particular reef fish, but also pelagic fish, is sold to middlemen and agents, i.e. owners of ice boxes, who bring the catch to the Honiara market, where it is sold. However, fishers may also organise their own trips to Honiara, provided that ice is available and quality assured. There are also agents who purchase trochus shells, another commercial fishery. In addition, some people travel to Honiara regularly or infrequently to sell a number of invertebrates, including trochus, mangrove oysters, mangrove mussels, crabs, lobsters and other species that are sought after locally. Marketing and processing of agricultural and seafood produce is limited due to the lack of electricity in the villages.

Moreover, Nggela's people also rely on agricultural production; people have access to communal agricultural land, and sell their agricultural produce at the Honiara market.

As elsewhere in Solomon Islands, very little reef fish is sold locally, but catch is shared among community members and provided for social and religious functions on a non-monetary basis.

2.2.1 The role of fisheries in the Nggela community: fishery demographics, income and seafood consumption patterns

Our results (Figure 2.2) suggest that the primary sector represents the most important income opportunities for the people of Nggela. As first income, agriculture plays the most important role (45% of all households), followed by fisheries (37% of all households). However, if taking into account first and second sources of household revenue, both agriculture and fisheries are similar, supplying 78% and 74% respectively of households in Nggela with first and second income. Salaries are unimportant and limited to the few employment opportunities associated with the small tourist resort on the island. Other income sources are also of minor importance and comprise handicrafts and betel nut and lime selling. Over 80% of households have 2–3 pigs on average and 35% of all households also have a couple of chickens for home consumption.

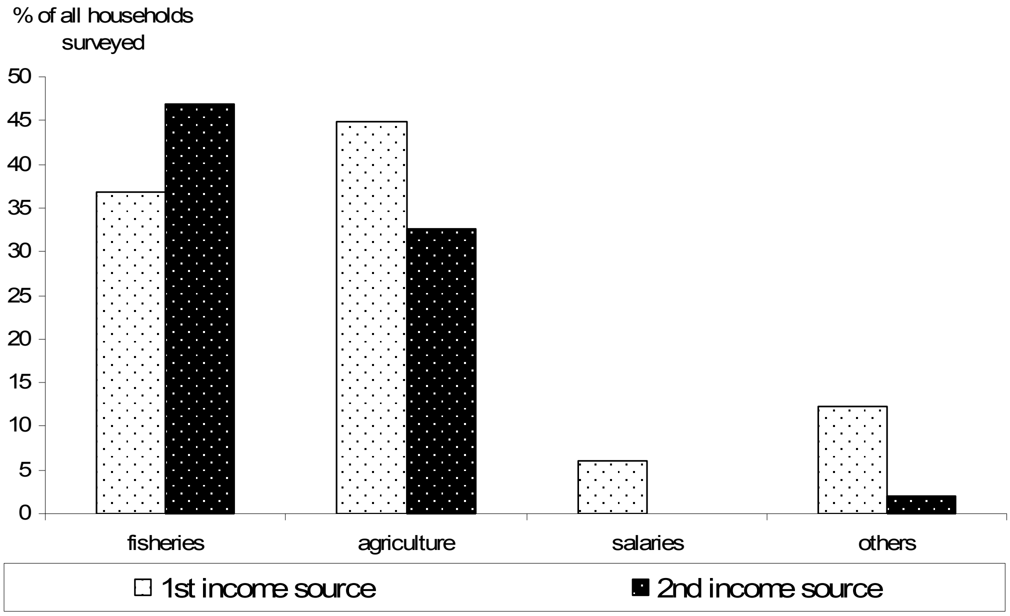

Figure 2.2: Ranked sources of income (%) in Nggela.
Total number of households = 49 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

Our results (Table 2.1) show that annual household expenditures are low with an average of USD 427. However, given the overall situation of all sites surveyed in Solomon Islands, Nggela is one of the communities with higher expenditures and thus better access to cash income opportunities. Remittances are important for Nggela's community, in particular for the people of Olevuga, where 60% of all households receive remittances of USD 1410 /year on average. However, if averaged over the total community, 20% of all households receive remittances, and those that fall in this category get an average of USD ~378 /year, representing 89% of the average household expenditure.

Table 2.1: Fishery demography, income and seafood consumption patterns in Nggela

Survey coverage	Site (n = 49 HH)	Average across sites (n = 182 HH)
Demography		
HH involved in reef fisheries (%)	100.0	99.5
Number of fishers per HH	3.04 (±0.26)	3.24 (±0.12)
Male finfish fishers per HH (%)	11.4	17.0
Female finfish fishers per HH (%)	0.0	2.2
Male invertebrate fishers per HH (%)	0.0	0.2
Female invertebrate fishers per HH (%)	14.8	9.0
Male finfish and invertebrate fishers per HH (%)	45.6	39.6
Female finfish and invertebrate fishers per HH (%)	28.2	32.1
Income		
HH with fisheries as 1st income (%)	36.7	30.2
HH with fisheries as 2nd income (%)	46.9	32.4
HH with agriculture as 1st income (%)	44.9	33.5
HH with agriculture as 2nd income (%)	32.7	31.9
HH with salary as 1st income (%)	6.1	11.0
HH with salary as 2nd income (%)	0.0	0.5
HH with other source as 1st income (%)	12.2	24.2
HH with other source as 2nd income (%)	2.0	12.1
Expenditure (USD/year/HH)	426.96 (±52.70)	404.22 (±22.58)
Remittance (USD/year/HH) (1)	377.95 (±143.38)	258.35 (±55.85)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	98.62 (±7.01)	104.78 (±4.00)
Frequency fresh fish consumed (times/week)	3.47 (±0.09)	3.57 (±0.05)
Quantity fresh invertebrate consumed (kg/capita/year)	14.63 (±1.75)	10.13 (±4.00)
Frequency fresh invertebrate consumed (times/week)	1.21 (±0.12)	1.20 (±0.06)
Quantity canned fish consumed (kg/capita/year)	3.57 (±0.65)	3.75 (±0.34)
Frequency canned fish consumed (times/week)	0.81 (±0.15)	0.85 (±0.07)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	98.0	95.6
HH eat canned fish (%)	61.2	75.3
HH eat fresh fish they catch (%)	100.0	97.6
HH eat fresh fish they buy (%)	22.4	21.4
HH eat fresh fish they are given (%)	26.5	71.4
HH eat fresh invertebrates they catch (%)	95.9	71.4
HH eat fresh invertebrates they buy (%)	4.1	0.0
HH eat fresh invertebrates they are given (%)	16.3	47.6

HH = household; (1) average sum for households that receive remittances; numbers in brackets are standard error.

Survey results indicate an average of 3 fishers per household, and when extrapolated the total number of fishers in Nggela is 851 including 486 males and 365 females. Among these are 97 exclusive finfish fishers (males only), 126 exclusive invertebrate fishers (females only), and 629 fishers who fish for both finfish and invertebrates (389 males, 240 females). Almost all households (94%) own a boat. Most (~75%) are non-motorised canoes; only ~25% are equipped with an outboard engine.

Consumption of fresh fish is high with ~99 kg/person/year, which is comparative to the average across all four study sites in Solomon Islands, but significantly lower than the assumed average for Solomon Islands of 40 kg (Gillet and Lightfoot 2001) to 45.5 kg/person/year (FAO 2008), or the regional average of ~35 kg/person/year (Figure 2.3).

By comparison, consumption of invertebrates (edible meat weight only) (Figure 2.4) is higher than in all other sites, with 14.6 kg/person/year. Canned fish (Table 2.1) adds only 3.6 kg/person/year to the protein supply from seafood. The consumption pattern of seafood found in Nggela highlights the fact that people have access to agricultural and fishery resources. People produce crops and catch enough fish to be self-sufficient in food. *Cassava*, *taro*, *pana*, *kumara*, *uvi* and *vudi* were found to be the main staple crops locally produced, with rice as a common alternative to root crops. Frozen foods or any other imported food is hardly ever consumed due to the limited cash income and purchasing power, and the lack of electricity and ice-making facilities.

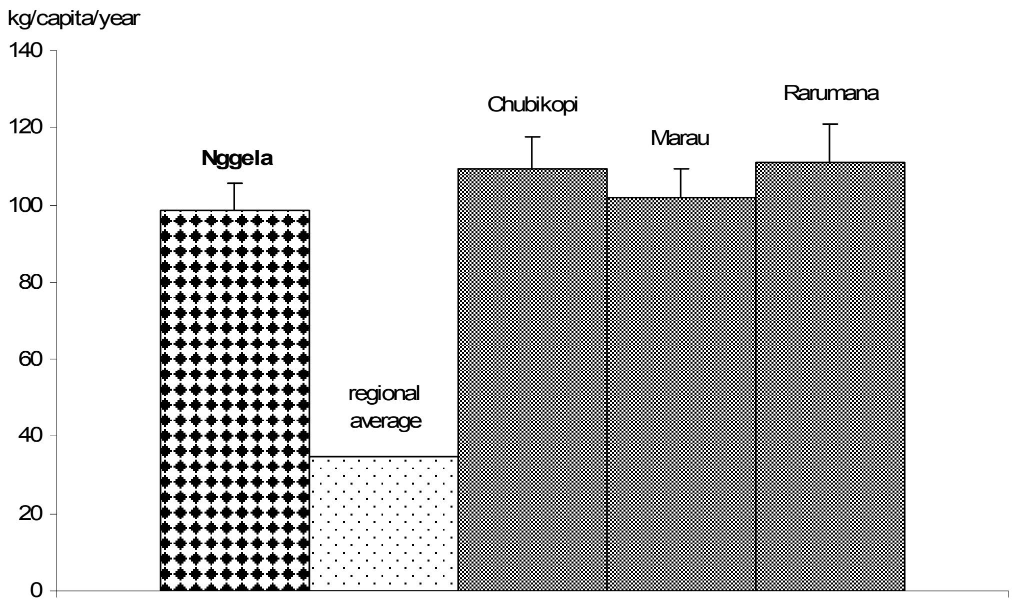

Figure 2.3: Per capita consumption (kg/year) of fresh fish in Nggela (n = 49) compared to the regional average (FAO 2008) and the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

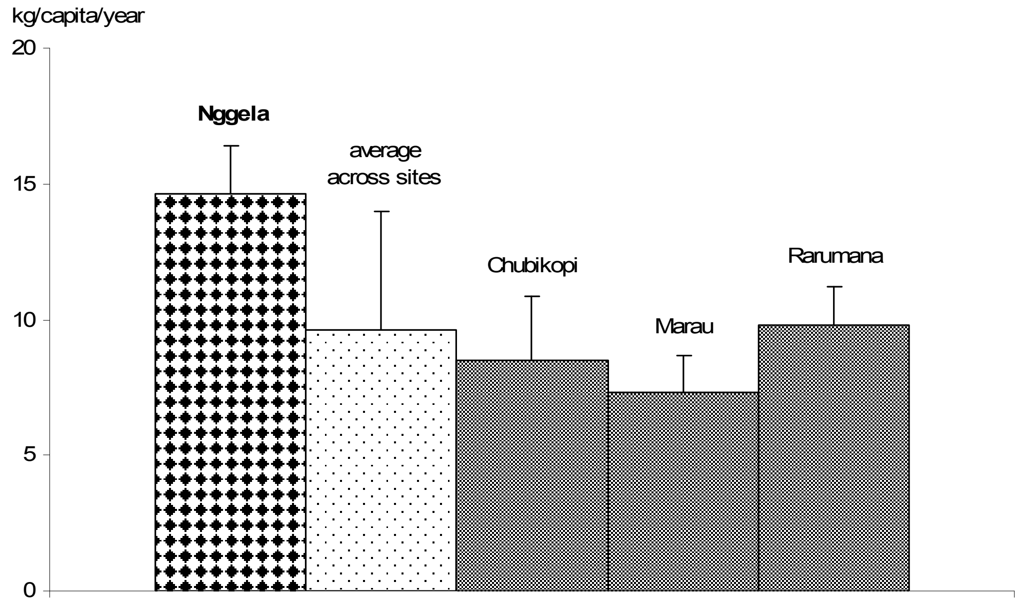

Figure 2.4: Per capita consumption (kg/year) of invertebrates (meat only) in Nggela (n = 49) compared to the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results with the average figures across all four study sites surveyed in Solomon Islands, people of the Nggela community eat fresh fish, invertebrates and canned fish about as often as found on average. However, while they eat slightly less fresh fish is slightly lower, they eat more invertebrates than average. Sharing seafood among community members on a non-monetary basis is very common but is practised less often than average for both finfish and invertebrates. Income from fisheries and agriculture plays a much greater role than elsewhere, highlighting the fact that Nggela is the closest site to the Honiara market. Consequently, people are much less engaged in handicrafts, wood carving and other alternative income activities than observed elsewhere. By comparison, boat ownership and the dominance of non-motorised canoes is about average; however, Nggela's people have the highest proportion of motorised boats.

2.2.2 Fishing strategies and gear: Nggela

Degree of specialisation in fishing

The management of marine resources is divided between the governmental legal and the traditional village system. The international NGO Foundation of the Peoples of the South Pacific International (FSPI) was active in Nggela during the time of the survey. FSPI, together with a number of local villages, introduced community-based management practices. Community-monitoring focal points were also established to assist in the monitoring and reporting of any of the agreed management activities. The Fisheries Department and FSPI worked closely together.

Fishing is not only one of the most important income sources; it is also the most important source of protein and calories. Fisheries produce is also important for social coherence as it is regularly exchanged among community members as a gift, although this happens much less in Nggela than was observed elsewhere in Solomon Islands. Traditional gender roles do not apply, but tradition demands for work to be shared by both males and females. With marriage, a female is expected to work for her husband's family.

However, there is a split between males' and females' engagement in fisheries as found elsewhere in the Pacific. Only males exclusively fish for finfish, and only females exclusively fish for invertebrates. However, most fishers, males and females, do both invertebrate harvesting and finfish fishing (Figure 2.5). Also, children participate in subsistence fisheries on a regular basis, mostly during school holidays and on weekends; while accompanying their parents, they learn traditional skills and knowledge.

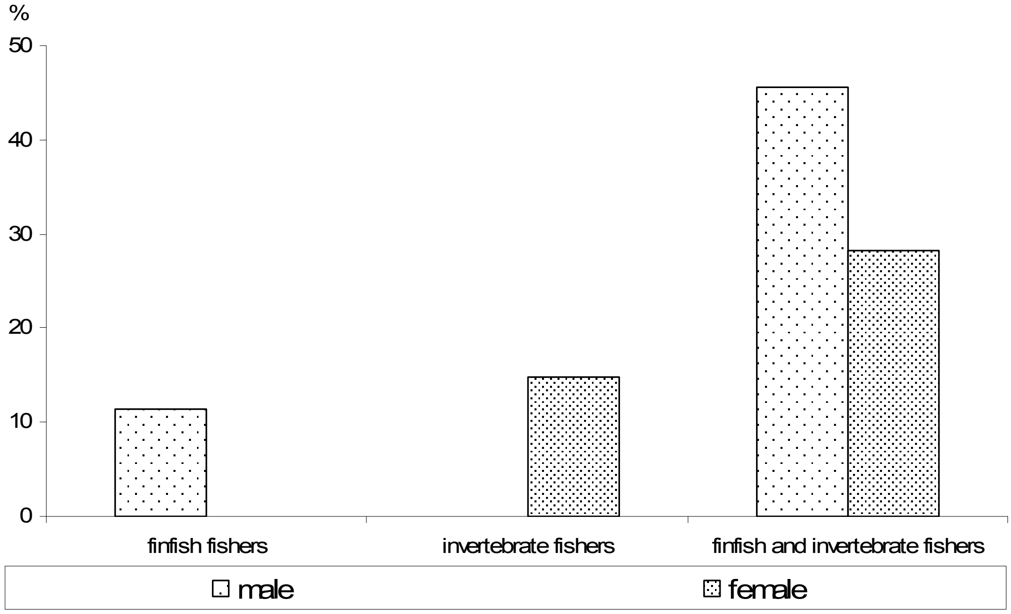

Figure 2.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Nggela.
All fishers = 100%.

Targeted stocks/habitat

Boats, here mainly non-motorised canoes, are essential for transport, fishing and gardening. Most of the fishing is done in the sheltered coastal areas and lagoon (~77% of all male fishers and 100% of female fishers). If the outer reef is targeted, travel time is longer, exposure to sea and weather conditions is higher, often motorised boats are used, and only male fishers (62%) target these habitats. Table 2.2 shows that the community has access to a great number of habitats that support a great variety of invertebrates. Interviews showed that invertebrate collection serves both home consumption and income needs and therefore targets a wide range of species and habitats. Usually, fishers visit a combination of several habitats during one fishing trip. Reeftop gleaning and diving for mainly giant clams and lobsters (the 'other' fishery) attract most males (~30%) and ~33% of all females, followed by soft benthos and mangrove gleaning, which attracts most female fishers (77%) and about one-third of all males. Only a few male fishers specialise in commercial invertebrate fisheries, such as trochus and lobster harvesting; however, if trochus collection is combined with diving for giant clams and lobsters, about 30% of all male fishers participate. Low participation in an income-earning fishery, i.e. the exclusive trochus and lobster diving fishery, may suggest that resource status is low and thus productivity and profitability are also low.

Table 2.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Nggela

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	7.7	0.0
	Sheltered coastal reef & lagoon	65.4	100.0
	Lagoon	3.8	0.0
	Lagoon & outer reef	11.5	0.0
	Outer reef	57.7	0.0
	Outer reef & passage	3.8	0.0
Invertebrates	Reeftop	0.0	9.5
	Reeftop & lobster & other	2.2	0.0
	Reeftop & other	28.3	23.8
	Reeftop & trochus	2.2	0.0
	Reeftop & trochus & other	10.9	0.0
	Intertidal	2.2	0.0
	Intertidal & reeftop	2.2	35.7
	Intertidal & reeftop & other	13.0	28.6
	Intertidal & reeftop & trochus & other	2.2	0.0
	Soft benthos	2.2	0.0
	Soft benthos & mangrove	10.9	64.3
	Soft benthos & reeftop	0.0	2.4
	Mangrove	15.2	7.1
	Mangrove & other	0.0	2.4
	Bêche-de-mer	2.2	0.0
	Bêche-de-mer & other	2.2	0.0
	Bêche-de-mer & trochus & other	2.2	0.0
	Trochus	4.3	0.0
	Trochus & lobster & other	2.2	0.0
	Trochus & other	28.3	0.0
	Lobster	8.7	0.0
	Other	6.5	0.0

'Other' refers to the lobster and giant clam fisheries.
Finfish fisher interviews, males: n = 26; females: n = 10. Invertebrate fisher interviews, males: n = 46; females, n = 42.

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip are the basic factors used to estimate the fishing pressure imposed by people from Nggela on their fishing grounds (Tables 2.2 and 2.3).

Our survey sample suggests that fishers from Nggela have a good choice among sheltered coastal reef, lagoon and outer reef fishing, including passages. As mentioned above, the same is true for invertebrate collection, as the community has access to intertidal, soft benthos, reeftop, lagoon and mangrove areas (Figure 2.6). 'Other', representing 23% of the invertebrate fishery, is basically diving for giant clams and lobsters. Gender separation only shows in the fact that only male fishers dive for invertebrates as an exclusive fishery. This category includes lobsters, trochus and 'other' (giant clams, lobsters). However, female fishers in Nggela do dive, but only in combination with gleaning and other techniques (Figure 2.7).

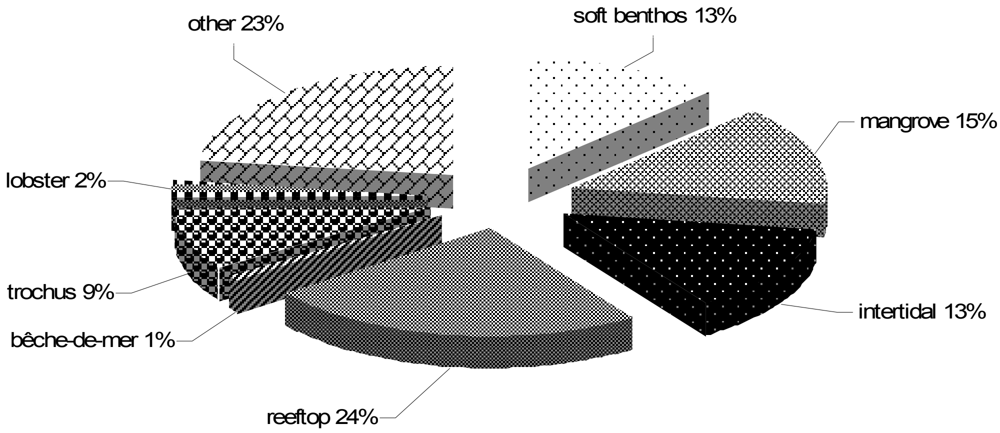

Figure 2.6: Proportion (%) of fishers targeting the eight primary invertebrate habitats found in Nggela.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the lobster and giant clam fisheries.

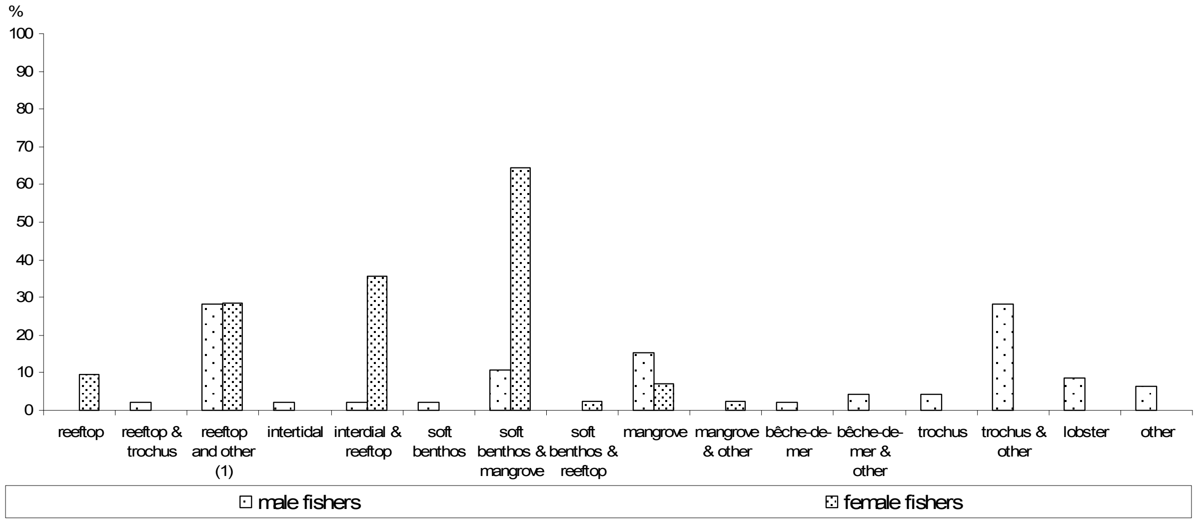

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Nggela.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 46 for males, n = 42 for females; 'other' refers to the lobster and giant clam fisheries.

Gear

Figure 2.8 shows that Nggela fishers use a variety of different gear, that they may combine different fishing techniques if catching fish in a particular habitat, and that low-cost fishing equipment is mainly used. For the combined fishing of sheltered coastal reef and lagoon areas, handlining and spear diving are the main techniques. In the lagoon, handlining may be combined with spear diving, handheld spearing, castnetting, gillnetting, and trolling. The combination of sheltered coastal and outer reef fishing uses castnets, also for catching bait, and handlining. Outer reef fishing is mainly done by handlining, deep-bottom lining and trolling. Spear diving is practised here as well, but not to a great extent (Figure 2.8). Most fishers targeting the outer reef target pelagic species, which are not the subject of this study.

Most invertebrate collection involves very simple techniques, such as digging, collecting by hand or netting in tidal pools, seagrass beds, mangroves, and sand and mud flats, using sticks, knives and other available tools.

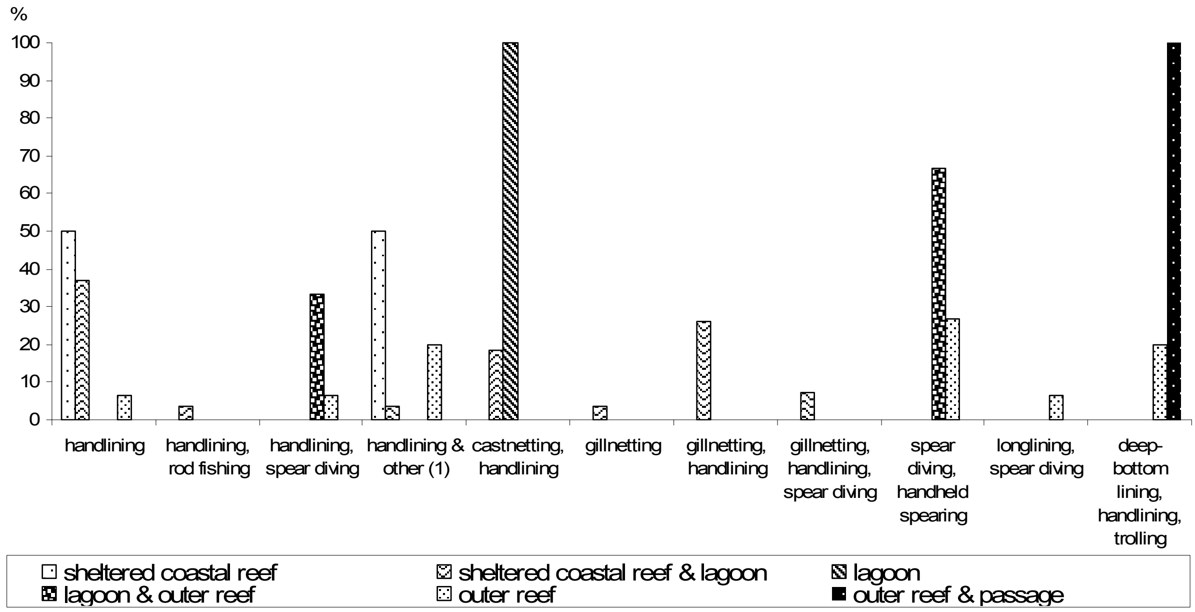

Figure 2.8: Fishing methods commonly used in different habitat types in Nggela.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip. 'Other' refers to spear diving, trolling and handheld spearing.

Frequency and duration of fishing trips

Finfish fishers, males and females, fish in any of the finfish habitats about twice per week on average. As shown in Table 2.3, the fact that an average fishing trip targeting the outer reef, or a combination of lagoon and outer reef takes longer (5–6 hours) may explain why female fishers fish in the habitats closer to shore. Here, there is no marked difference between gender groups; both spend on an average 3–4 hours per fishing trip.

Concerning invertebrate harvesting, fishing trips are performed less often than trips for finfish. Both male and female fishers harvest invertebrates about once a week. Specialised commercial fisheries, including trochus and lobster, are less frequently pursued, i.e. about once a fortnight, or once a month. However, if trochus is collected in combination with diving for lobsters and giant clams, fishers may go out almost once a week. The most frequently visited habitat is the reeftop, and this observation applies for both male and female fishers. On average, an invertebrate collection trip takes ~3–4 hours, depending on whether diving activities and thus further travel time to more distant fishing grounds are involved. The longest fishing trips made by females are those to the mangroves and soft benthos and the longest trips made by male fishers are those targetting lobsters, trochus, bêche-de-mer and the combined diving for a number of commercial species (Table 2.3).

The frequency and duration of fishing trips may also be determined by the use of boats. Canoes are used for most finfish fishing trips closer to shore and motorised boats are used for outer-reef and passage fishing trips. Boats may also be borrowed from other community members. Most finfish fishing is done during the day and tidal conditions are the most important factor for choosing the right time to fish at the outer reef and passages. The preference for daytime fishing is very much influenced by the threat of crocodiles. This applies in particular to areas close to or inside mangrove swamps and habitats closer to shore. Finfish fishing is performed throughout the year and combined and interwoven with agricultural activities. The use of ice during fishing trips is not a standard practice, but ice is often used on fishing trips targeting the lagoon area. As elsewhere, the purchase of ice if available at all is difficult. It seems, however, that the use of ice by Nggela fishers is more widespread than observed elsewhere. This may be explained by the close proximity to the Honiara market, and presumably better infrastructure than in more remote sites.

Almost all invertebrate collection is done by using a canoe to reach the fishing ground or to support diving and collection activities. Usually, invertebrates are collected all year round. Almost all activities are exclusively performed during the day, but most lobster diving, intertidal collection and the occasional dive trip for a number of commercial species are undertaken at night. The presence of crocodiles is the main reason why invertebrates are almost exclusively fished during the day, particularly in mangrove areas and muddy water.

Table 2.3: Average frequency and duration of fishing trips reported by male and female fishers in Nggela

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	2.25 (±0.75)		3.50 (±0.50)	
	Sheltered coastal reef & lagoon	1.85 (±0.13)	2.20 (±0.19)	3.29 (±0.29)	3.00 (±0.21)
	Lagoon	2.00 (n/a)	0	4.00 (n/a)	0
	Lagoon & outer reef	2.33 (±0.33)	0	3.33 (±0.33)	0
	Outer reef	1.70 (±0.14)	0	5.33 (±0.19)	0
	Outer reef & passage	2.00 (n/a)	0	6.00 (n/a)	0
Invertebrates	Reeftop	0	1.25 (±0.25)	0	3.50 (±0.29)
	Reeftop & lobster & other	2.00 (n/a)	0	3.00 (n/a)	0
	Reeftop & other	0.88 (±0.13)	0.94 (±0.15)	3.23 (±0.12)	3.20 (±0.13)
	Reeftop & trochus	1.00 (n/a)	0	3.00 (n/a)	0
	Reeftop & trochus & other	1.70 (±0.30)	0	3.20 (±0.20)	0
	Intertidal	0.46 (n/a)	0	2.00 (n/a)	0
	Intertidal & reeftop	1.00 (n/a)	1.00 (±0.15)	3.00 (n/a)	3.07 (±0.12)
	Intertidal & reeftop & other	1.08 (±0.20)	1.67 (±0.26)	3.33 (±0.42)	3.42 (±0.15)
	Intertidal & reeftop & other & trochus	1.00 (n/a)	0	4.00 (n/a)	0
	Soft benthos	1.00 (n/a)	0	3.00 (n/a)	0
	Soft benthos & mangrove	0.64 (±0.15)	1.21 (±0.11)	3.80 (±0.20)	3.59 (±0.15)
	Soft benthos & reeftop	0	0.92 (n/a)	0	3.00 (n/a)
	Mangrove	0.70 (±0.12)	1.00 (±0.00)	3.14 (±0.51)	3.67 (±0.67)
	Mangrove & other	0	0.46 (n/a)	0	3.00 (n/a)
	Bêche-de-mer	0.46 (n/a)	0	3.00 (n/a)	0
	Bêche-de-mer & other	0.46 (n/a)	0	4.00 (n/a)	0
	Bêche-de-mer & trochus & other	0.69 (n/a)	0	3.00 (n/a)	0
	Lobster	0.18 (±0.05)	0	4.75 (±0.25)	0
	Trochus	0.46 (±0.00)	0	4.00 (±0.00)	0
	Trochus & lobster & other	0.46 (n/a)	0	4.00 (n/a)	0
	Trochus & other	0.75 (±0.19)	0	3.08 (±0.14)	0
	Other	0.61 (±0.08)	0	2.67 (±0.33)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the lobster and giant clam fisheries.
Finfish fisher interviews, males: n = 26; females: n = 10. Invertebrate fisher interviews, males: n = 46; females: n = 42.

2.2.3 Catch composition and volume – finfish: Nggela

The catches reported from the sheltered coastal reef alone are not very diverse and determined to a great extent (~75%) by a few species groups only, *Strongylura* sp., small Carangidae and Clupeidae (*kepo*) being the dominant ones. The catch reported for combining the sheltered coastal reef and lagoon in one fishing trip is diverse; one-third of the annual reported weight is represented by the Holocentridae *Myripristis* sp., and the two Serranidae: *Cephalopholis* spp. and *Epinephelus* spp. Lagoon and outer-reef catches are reported to be much less diverse and apart from *Crenimugil crenilabis* (Mugilidae) and *Parupeneus* sp. (Mullidae), there are several reef fish families present, such as Lethrinidae, Serranidae, Holocentridae, Lutjanidae and others. Finally, the outer reef catches are reported to be mainly represented by three species groups: *Carangoides* spp., *Epinephelus* spp. and *Cephalopholis* spp. Of course, there is a great number of other species listed, mainly reef but also some pelagic species. Carangidae and Sphyraenidae seem to be the most targeted families in the passages. The major observation in reviewing the reported catch composition taken by Nggela fishers is the almost total lack of Scaridae. Scaridae were not reported at all in catches from the sheltered coastal reef, or lagoon, or for the combined fishing of lagoon and outer reef. They were reported to contribute only 4% to catches from the combined fishing of the sheltered coastal reef and lagoon, and 1% to catches from the outer reef. This observation raises concern about resource status, in particular as spear diving is a technique used in several habitats. Scaridae are expected in association with coral reefs; however, they are also very easy targets for spear diving at night. It should also be noted that access to both marketing and open-ocean resources has triggered heavy involvement in deep-bottom and oceanic fishing. Some of these catches are interwoven with reef fisheries and are reported here. Others, exclusive pelagic fisheries, are not the subject of this study. Detailed information on catch compositions by species, species groups and habitats are reported in Appendix 2.1.1.

Figure 2.9 highlights findings from the socioeconomic survey reported earlier, that finfish fishing serves not only subsistence needs but is also very important for generating income. The total annual catch is estimated to amount to ~270 t, of which ~57% is used for subsistence needs, while ~43% is sold to the Honiara market. While participation in finfish fisheries did not vary much between gender groups, male fishers account for 81% of the total catch; female fishers provide ~19% only. As reported earlier, the preference of female fishers to stay closer to shore also shows in the accumulated impact of both gender groups, i.e. ~60% of the total impact is imposed on the sheltered coastal reef and lagoon. The remaining ~40% is partly due to the lagoon (combined lagoon and outer-reef fishing accounts for ~6% of the total reported catch), but a substantial amount (33%) is accounted for by outer-reef and passage fishing.

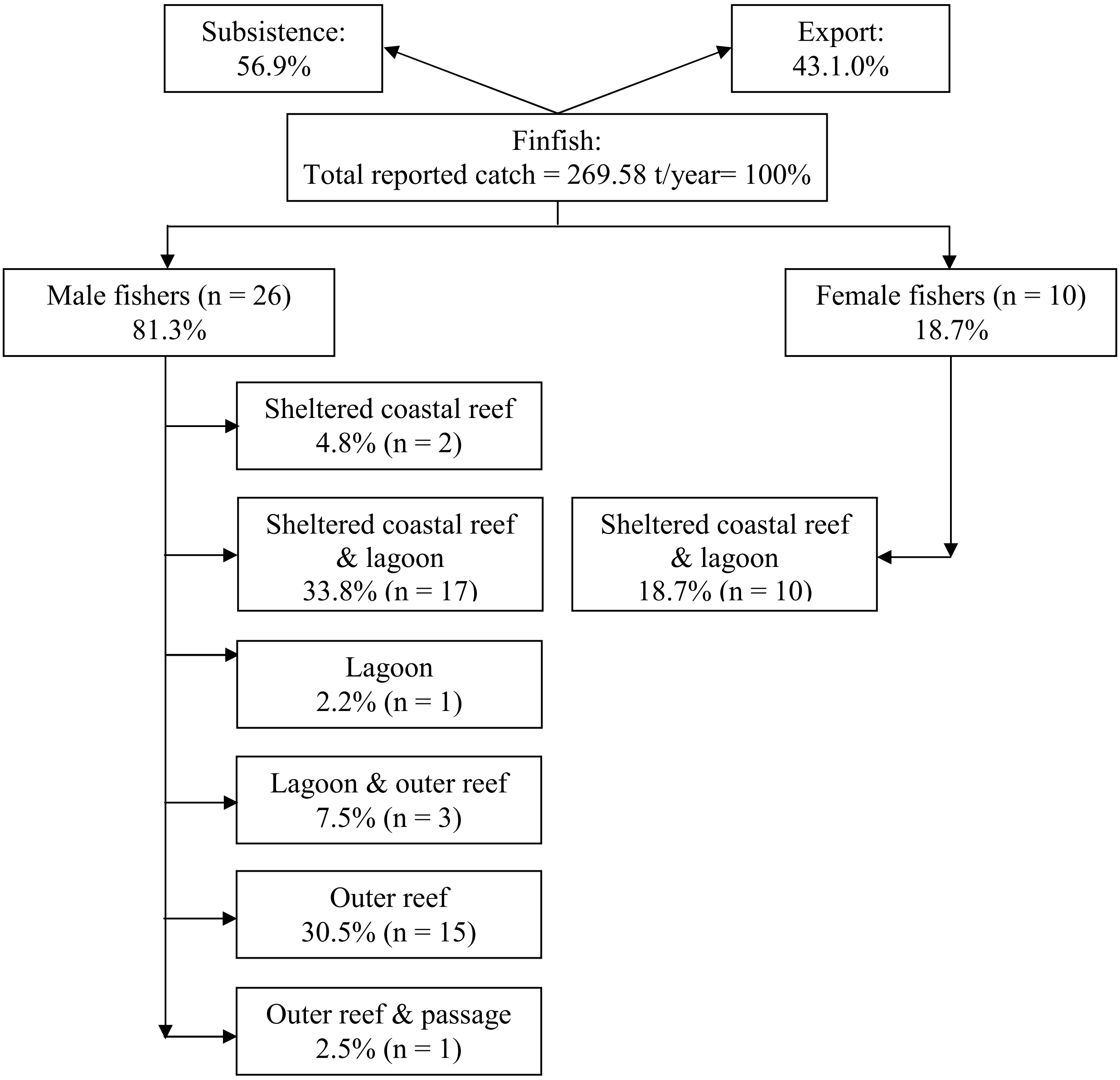

Figure 2.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Nggela.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The distribution of annual catch weight between the more easily accessible sheltered coastal reef and lagoon, and the more distant outer reef, is a consequence of the number of fishers rather than differences in the annual catch rates. As shown in Figure 2.10, the average annual catch per fisher does not vary substantially between areas closer to shore and the outer reef. While the average annual catch per fisher targeting the sheltered coastal reef alone or in combination with the lagoon amounts to ~400 kg, the combined fishing of lagoon and outer reef or outer reef fishing alone or in combination with passage fishing, renders ~450 kg/fisher/year on average. The difference in average annual catch between male and female fishers is also not pronounced if comparing figures for the same habitats fished, i.e. the combined sheltered coastal reef and lagoon areas.

Comparing productivity rates between genders and among habitats (Figure 2.11) shows no obvious differences between male and female fishers. However, overall, CPUEs are low and hardly exceed 1.5 kg/hour of fishing trip, which may be a result of the use of non-motorised canoes and low-cost fishing gear, which are less efficient. The low CPUEs may also suggest a low resource status. Interestingly, CPUE decreases with distance from shore, i.e. the CPUEs reported for outer-reef and passage fishing are lower than those reported for other habitats.

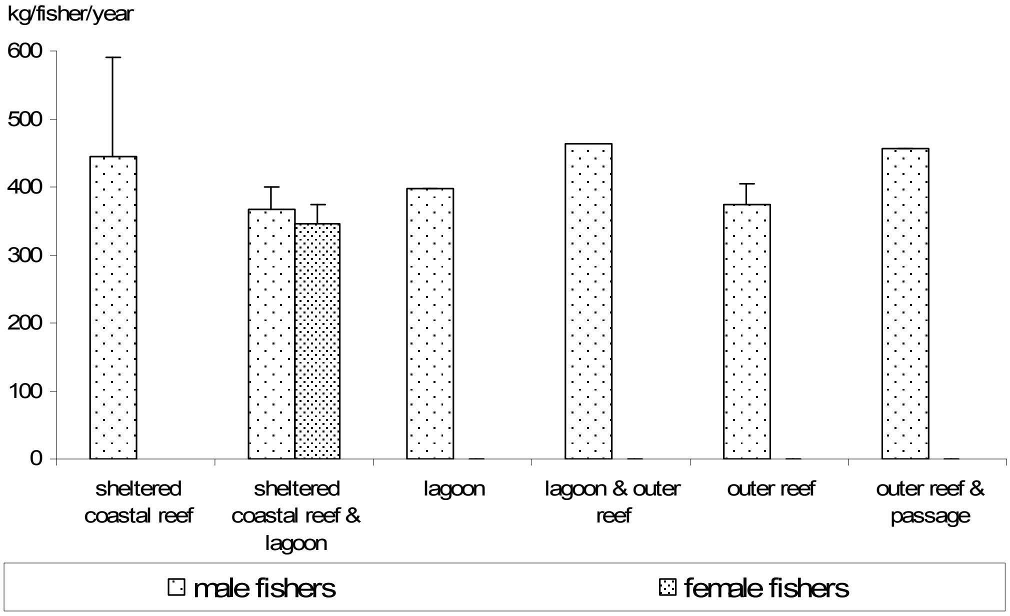

Figure 2.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Nggela (based on reported catch only).

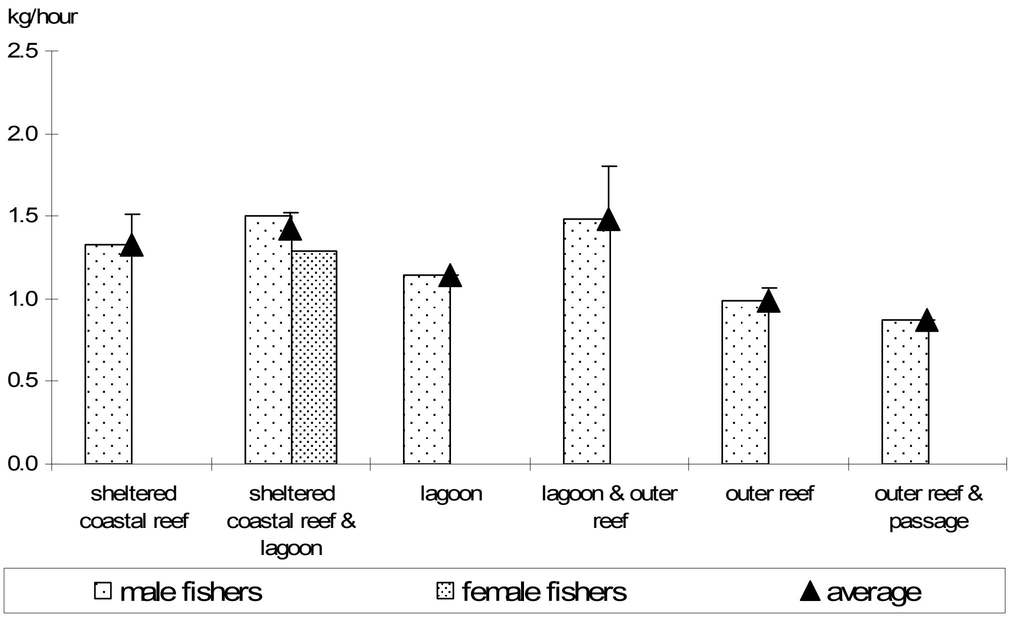

Figure 2.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Nggela.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The almost equal importance of subsistence and commercial fishing for Nggela people clearly shows in Figure 2.12. In contrast to results from other PROCFish sites in the Solomon Islands, fishing trips targeting the sheltered coastal reef and lagoon are highly commercial. However, as observed elsewhere, male fishers targeting the outer reef, or the outer reef and passages, mainly fish in order to generate income. Social interests seem to decline with fishing further from shore, and fishing for family needs seems to be more important for sheltered coastal reef and lagoon fishers as well.

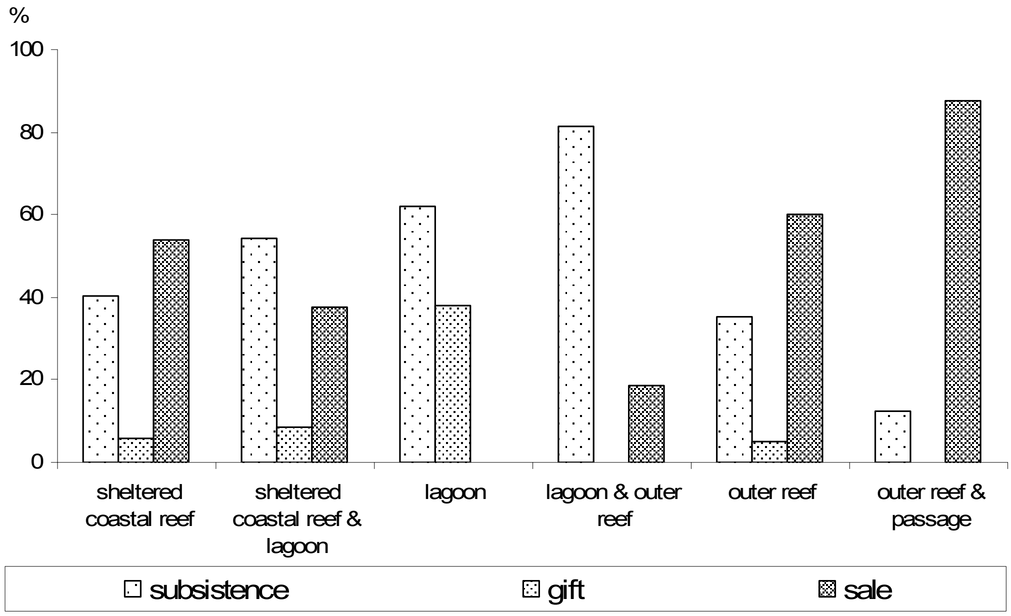

Figure 2.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Nggela. Proportions are expressed in % of the total number of trips per habitat.

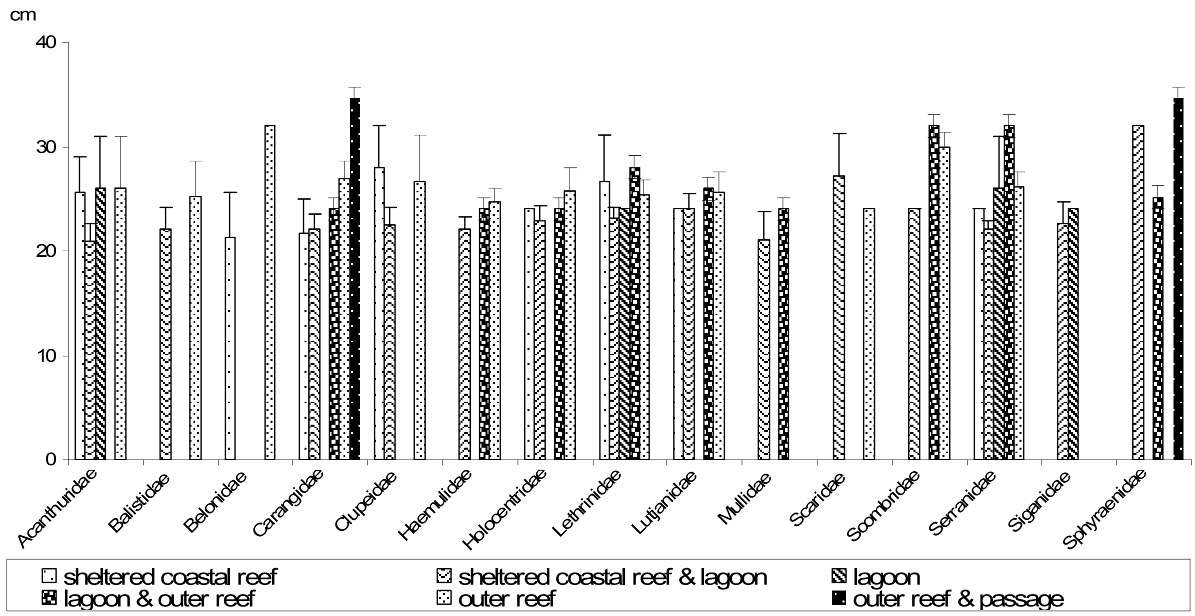

Figure 2.13: Average sizes (cm fork length) of fish caught by family and habitat in Nggela. Bars represent standard error (+SE).

Comparison of the overall finfish fishing productivity among habitats, and the absence of Scaridae from reported catches, indicate detrimental effects from previous fishing and a rather low resource status (Figure 2.11). If comparing the reported average fish size across all habitats (Figure 2.13), some of the families also show suspicious trends. While average fish size reported for Carangidae increases with distance from shore, which is the normal trend, this is not necessarily true for all of the reported reef fish families. Acanthuridae seem not to vary in average fish size among habitats and, in the case of Serranidae, Scombridae and Lethrinidae, average fish size seems to decrease with distance from shore, which indicates an impact from fishing. The expected trend still shows for Holocentridae and to some extent at least for Lutjanidae. Also the average reported fish length varies significantly; for some families it is ~20–25 cm, while for others it is ~30 cm.

The selection of indicators to assess current fishing pressure on Nggela's reef and lagoon resources is shown in Table 2.4. Most fishers target either the combined sheltered coastal reef separately or in combination with the lagoon. While this classification is a fisher's perception of their environment, geomorphological classification only distinguishes between a very limited coastal and a much larger outer-reef area. Nevertheless, calculations show that fisher density is extremely high on the coastal reef areas, but low to moderate in the outer reef and passages (1–19 fishers/km²). Overall, fisher and population densities per the community's total reef surfaces (equals total fishing ground) are high by any standard (66 fishers/km² and 171 people/km²). Subsistence catch per reef area is 14–15 t/year and must be regarded as exceeding sustainable reef production. This assumption is particularly highlighted by the fact that subsistence demand is only about half of the total annual catch; thus, the total catch per unit area is about double.

Table 2.4: Parameters used in assessing fishing pressure on finfish resources in Nggela

Parameters	Habitat					
	Sheltered coastal reef (4)	Lagoon & outer reef	Outer reef	Outer reef & passage (5)	Total reef area	Total fishing ground
Fishing ground area (km²)	1.09	n/a	9.96	9.96	11.05	11.05
Density of fishers (number of fishers/km² fishing ground) (1)	449	n/a	19	1	66	66
Population density (people/km²) (2)					171	171
Average annual finfish catch (kg/fisher/year) (3)	445.45 (±145.27)	463.32 (±36.89)	375.04 (±30.24)	456.17 (n/a)		
Total fishing pressure of subsistence catches (t/km²)					14.5	14.5
Total number of fishers	489	37	187	12	726	726

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1891; total number of fishers = 726; total subsistence demand = 160.1 t/year; (3) catch figures are based on recorded data from survey respondents only; (4) sheltered coastal reef includes 452 fishers considering this unit as sheltered coastal reef & lagoon system (average annual catch per fisher: 358.61 (±23.02)), and 12 fishers considering fishing in the lagoon (average annual catch per fisher: 397.46 (n/a)); (5) outer reef surface considered only.

2.2.4 Catch composition and volume – invertebrates: Nggela

Calculating catches reported from invertebrate fishers by wet weight shows a different picture to that in any of the other study sites in Solomon Islands. A number of species are heavily exploited. *Keu*, giant clams, *Holothuria* spp., *Pinna bicolor*, trochus, *kuta* and lobsters are the main species by wet weight, each being reported to account for >4–16 t/year. *Tripneustes gratilla*, *Strombus luhuanus*, *Scylla serrata*, octopus and *Cardisoma* spp. make up another substantial annual impact by wet weight with ~1–4 t/year. In addition, there are many other target species with less impact (Figure 2.14).

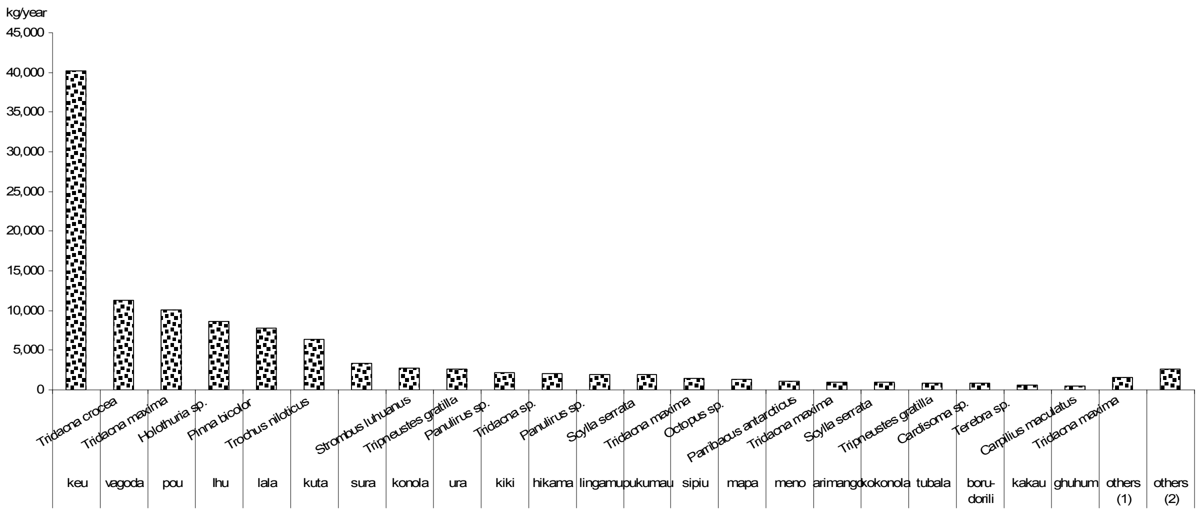

Figure 2.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Nggela.
'Others (1)' include species with 300–500 kg reported catch per year (wet weight);
'others (2)' include species with ≤300 kg reported catch per year (wet weight).

The fact that Nggela fishers target a wide range of species across many habitats is also shown by the number of vernacular names that have been registered from respondents. Reeftop gleaning and diving (for mostly reef-associated species) has the highest number of vernacular names (24), and mangrove and soft-benthos fishing has 13 vernacular names. Others, either focusing on one habitat or a particular commercial fishery are less diverse and include a few reported vernacular names only (Figure 2.15).

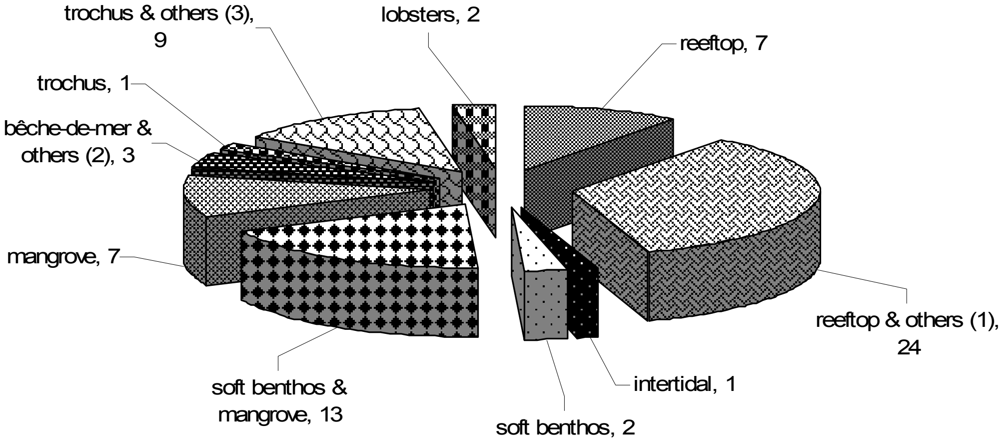

Figure 2.15: Number of vernacular names recorded for each invertebrate fishery in Nggela.
'Others (1)' refer to trochus, intertidal and soft benthos; 'others (2)' refer to trochus; 'others (3)' refer to lobsters.

The average annual catch per fisher by gender and fishery (Figure 2.16) reveals substantial differences among fisheries. Most fisheries produce annual average catches of ~300–600 kg. However, the combined fishing of soft benthos and reeftop, bêche-de-mer & 'others', bêche-de-mer & trochus & 'others', reeftop & trochus & 'others' and reeftop & lobster & 'others' yield 1.2–1.6 t/fisher/year (wet weight). It should be noted that some of these figures are obtained from one or only a few interviews. Thus, these results should be used with caution. While high annual average catches from soft benthos & reeftop are taken by female fishers, all other high annual average catch rates are due to male fishers' activities. Because participation by males and females in the various fisheries and combinations thereof differs substantially, average annual catch rates cannot be compared by gender and fishery.

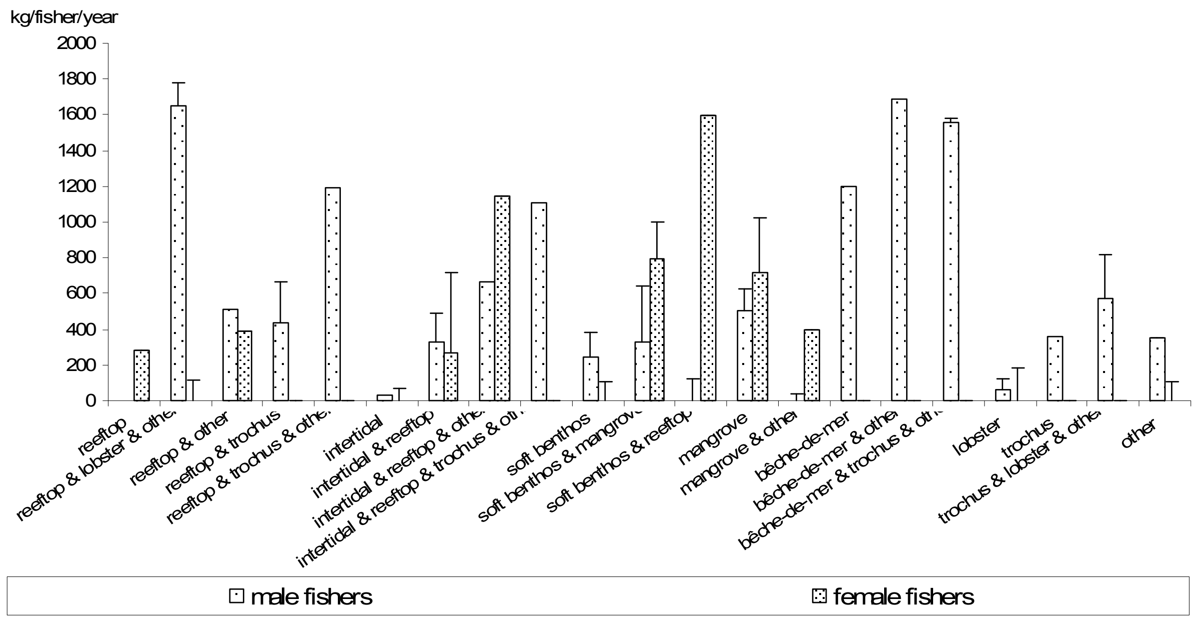

Figure 2.16: Average annual invertebrate catch (kg wet weight/year) in reeftop habitat by fisher and gender in Nggela.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 46 for males, n = 42 for females).

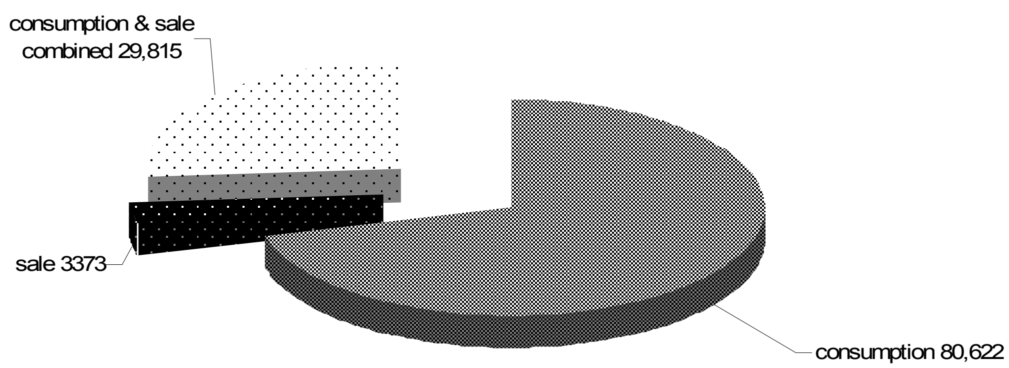

Figure 2.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Nggela.

The above observation that invertebrate collection mainly serves subsistence needs and, to some extent, also income generation is confirmed by results shown in Figure 2.17. The proportion of the invertebrate catch that is sold on the local markets may not exceed 16% of the total annual reported catch or 18,281 kg/year if assuming that half of the share that may be consumed or sold is indeed sold. There is no record for a species or a catch that is exclusively collected for sale. This also applies for trochus as the meat is locally consumed, while the shells are sold.

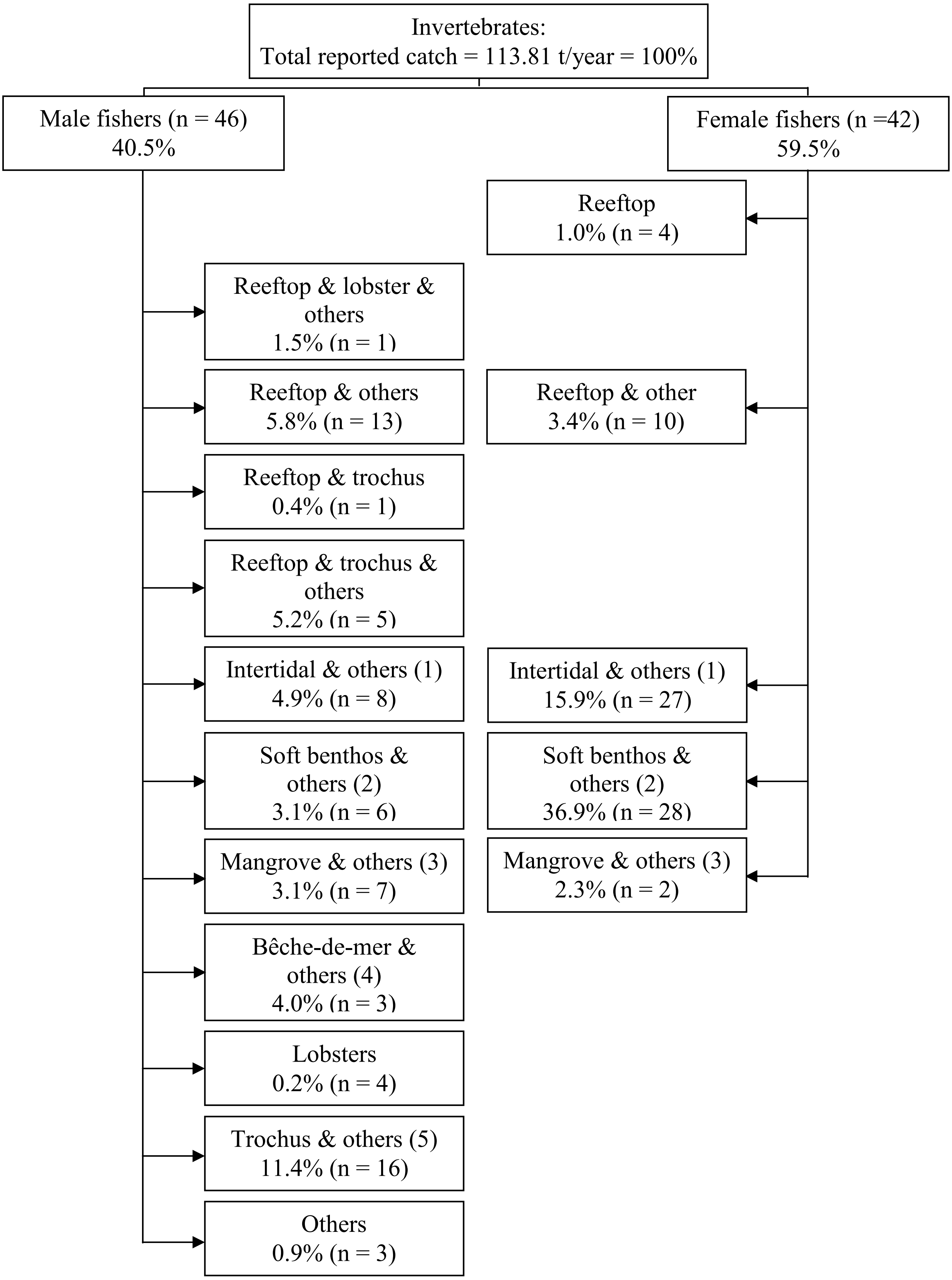

Figure 2.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Nggela.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. 'Others' refers to lobster and giant clams; (1) intertidal & reeftop, intertidal & reeftop & other, intertidal & reeftop & trochus & other; (2) soft benthos & mangrove, soft benthos & reeftop; (3) mangrove, mangrove & other; (4) bêche-de-mer, bêche-de-mer & other, bêche-de-mer & trochus & other; (5) trochus, trochus & lobster & other, trochus & other.

As mentioned earlier, male fishers from Nggela are very much engaged in invertebrate fisheries. This shows in the proportion of total annual catch which males account for (40.5%), while females account for 59.5% (Figure 2.18). Most of Nggela male invertebrate fishers glean the reeftops and dive for giant clams, lobsters and trochus, or target trochus in combination with other species. In addition, there is a great range of collection activities that a few male fishers also pursue. Female fishers from Nggela mainly target the soft benthos in combination with other, particularly mangrove areas and, to a much lesser extent, reeftop and related habitats. Combining information from both gender groups, most harvesting by wet weight is from the reeftop and associated gleaning and diving fisheries, and soft-benthos and mangrove fisheries.

Based on the above findings, it is not surprising that the reeftop and soft-benthos fisheries show high fisher density. Roughly estimating all fishers who target the reeftop and associated fisheries, Nggela has at least a fisher density of ~46–50 fishers/km². There is also a great number of fishers, both males and females, targeting the soft-benthos and associated fisheries. While the surface areas of soft-benthos and mangrove habitats in Nggela are not known, the total number of fishers involved is large, i.e. ~380; therefore, a high fisher density can be assumed. Adding average annual catches reported per fisher and per fishery or combination of fisheries, fishing pressure in terms of catch per unit area for reeftop and associated fisheries, as well as for soft benthos and mangroves can be assumed high (Table 2.5). Furthermore, reported annual impact is focused on a few species only, including giant clams, *Holothuria* spp., *Pinna bicolor*, lobsters and others. While sea urchins and some bivalves and gastropods do have a high annual reproduction rate, others, such as giant clams, trochus and lobsters, are much more sensitive to fishing impact due to their long reproduction period. The reported average annual catches and, in particular, size distributions (Appendices 2.1.2 and 2.1.3) suggest poor resource status or at least noticeable detrimental effects of fishing on some of these species. Before final assessment is made, however, these results need to be compared with results from the resource surveys.

Table 2.5: Parameters used in assessing fishing pressure on invertebrate resources in Nggela

Parameters	Fishery / Habitat							
	Reeftop [(5)]	Reeftop & lobster & other [(3) + (5)]	Reeftop & other [(3) + (5)]	Reeftop & trochus [(3) + (5)]	Reeftop & trochus & other [(3) + (5)]	Intertidal	Intertidal & reeftop	Intertidal & reeftop & other
Fishing ground area (km^2)	3.47	7.15	7.15	7.15	7.15	n/a	n/a	n/a
Number of fishers (per fishery) [(1)]	35	8	197	8	42	8	139	155
Density of fishers (number of fishers/km^2 fishing ground)	10	1	28	1	6	n/a	n/a	n/a
Average annual invertebrate catch (kg/fisher/year) [(2)]	284.73 (±110.60)	1650.29 (n/a)	456.57 (±85.06)	437.69 (n/a)	1191.37 (±226.41)	34.16 (n/a)	289.07 (±73.95)	986.84 (±303.30)

Parameters	Fishery / Habitat							
	Intertidal & reeftop & trochus & other	Soft benthos	Soft benthos & mangrove	Soft benthos & reeftop	Mangrove	Mangrove & other	Bêche-de-mer	Bêche-de-mer & other
Fishing ground area (km^2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Number of fishers (per fishery) [(1)]	8	8	277	9	85	9	8	8
Density of fishers (number of fishers/km^2 fishing ground)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average annual invertebrate catch (kg/fisher/year) [(2)]	1107.43 (n/a)	244.50 (n/a)	1374.34 (±185.43)	1599.12 (n/a)	567.49 (±120.23)	399.78 (n/a)	1199.34 (n/a)	1689.07 (n/a)

Parameters	Fishery / Habitat					
	Bêche-de-mer & trochus & other	Trochus	Trochus & lobster & other	Trochus & other	Lobster [(4)]	Other [(3)]
Fishing ground area (km^2)	n/a	3.68	n/a	3.68	6.5	3.68
Number of fishers (per fishery) [(1)]	8	17	8	110	34	25
Density of fishers (number of fishers/km^2 fishing ground)	n/a	4.6	n/a	29.8	5.2	6.9
Average annual invertebrate catch (kg/fisher/year) [(2)]	1559.14 (n/a)	359.80 (±119.93)	569.69 (n/a)	898.23 (±243.87)	59.24 (±18.79)	349.14 (±36.24)

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; [(1)] total number of fishers is extrapolated from household surveys; [(2)] catch figures are based on recorded data from survey respondents only; [(3)] outer reef area; [(4)] outer-reef linear measurement (km); [(5)] oceanic fringing reef flat.

2.2.5 Discussion and conclusions: socioeconomics in Nggela

The Nggela community is not as isolated as the other PROCFish sites surveyed in Solomon Islands. The community's proximity to Honiara and the existing transport opportunities, although not easy, have made Nggela one of the most regular suppliers of seafood to the Honiara market. The community is distributed over a couple of villages on Sandfly Island, Central Island Province. People have access to communal agricultural land, which is as important as fisheries for food and income. In addition, income opportunities are provided by the aquarium fish trade (live corals), trochus, and a small tourist resort on the island. As the other communities surveyed, the Nggela community still leads a very self-sustained, low-income lifestyle with little purchasing power for imported food items. The lack of electricity limits the preservation and processing of agricultural and fishery produce. Fisheries produce is sold to middlemen and agents and, to a much lesser extent, sold directly to clients at the Honiara market. The fact that that there is an oversupply to the Honiara market keeps fish prices low. The bêche-de-mer fishery is temporarily closed nationwide, and income from the aquarium trade fishery is limited. Although trochus shells are still sought after for export, the average catches reported suggest that resource status is low, and thus income opportunities are dwindling. Agriculture is the most important income source; however, fisheries are almost the same, particularly if regarding both first and second income sources.

As elsewhere, management of marine resources and enforcement of regulations and rules are done at two levels: the national legal framework and traditional village rules. Fisheries management in Nggela is done in close cooperation with the communities, the international NGO FSPI and the Fisheries Department. Fisheries management aims to support community fisheries management planning and activities, and to monitor compliance and results. Community focal points have been established to assist in monitoring and reporting. In addition, there are still a number of traditional mechanisms to regulate resource use. In summary, survey results suggest:

- Nggela's population has an important dependence upon their marine resources for income and home consumption. Fresh fish consumption is high (98.6 kg/person/year) and represents the most important food and protein source. However, agriculture is even more important as income than fisheries, and also contributes substantially to the food supply of local families.

- Tradition does not demand particular gender roles, rather division of labour. However, as elsewhere in the Pacific, only females exclusively fish for invertebrates and only males exclusively fish for finfish. However, most fishers, males and females, fish for both finfish and invertebrates.

- Finfish is mainly sourced from the sheltered coastal reef and lagoon, mostly using non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers fishing commercially, and mostly using motorised boat transport. Deep-bottom and pelagic fisheries also provide substantial revenues, although these are not a subject of this study.

- Overall, CPUEs are low, ~1.3–1.5 kg fish/hour of fishing trip, due to inefficient fishing techniques, low-cost fishing gear, and/or low resource status. CPUEs reported for fishing at the outer reef and passages are lower than those from sheltered coastal reef and lagoon fishing.

- A wide range of traditional and mostly low-cost fishing techniques is used, often in combination. The average reported fish sizes for some families are 20–25 cm, for others ~30 cm. Most families show the expected increase in average fish size with distance from shore, but others show no differences in average size among habitats (Acanthuridae). For some families (Serranidae, Scombridae and Lethrinidae) average sizes actually decrease with distance from shore.

- Results from the invertebrate fisher survey show that catches of giant clams (in particular *Tridacna crocea* and *T. maxima*), *Holothuria* spp., *Pinna bicolor*, trochus, *Strombus* spp., sea urchins, and lobsters account for most of the annual harvest (wet weight). These species represent a mix of species used for commercial and subsistence needs. Some of these species, such as giant clams, lobsters and trochus, are sensitive to fishing pressure due to their long reproduction periods.

- In contrast to finfish fishing, significant differences were found in the average annual catches by invertebrate fishery. Catches reported from the combined gleaning and diving fisheries, soft benthos and 'other' fisheries, and bêche-de-mer and 'other' fisheries, are by far the largest, while average annual catches from all other fisheries are rather small.

- Fishing pressure indicators calculated for finfish fisheries suggest that, due to the available reef and overall fishing ground area, fisher and population densities and subsistence catch per available surface unit area are high. Fishing pressure was, however, lower at the outer reef and passages, and higher in the sheltered coastal reef and lagoon. Generally, the current exploitation level of invertebrates for subsistence and, to a lesser extent, for commercial use is high, and fisher density is high for reeftop gleaning and associated fisheries, as well as for soft benthos and 'other' fisheries combined. However, the reported average annual catches of trochus (trochus alone, not mixed with other catches) are low, and not many fishers are engaged in this commercial fishery, which suggests that resource status is low. A high if not detrimental fishing pressure is also assumed for giant clams, one of the most sought-after species.

2.3 Finfish resource surveys: Nggela

Finfish resources and associated habitats were assessed between 14 and 20 June 2006 from a total of 24 transects (6 outer-reef transects; see Figure 2.19 and Appendix 3.1.1 for transect locations and coordinates respectively).

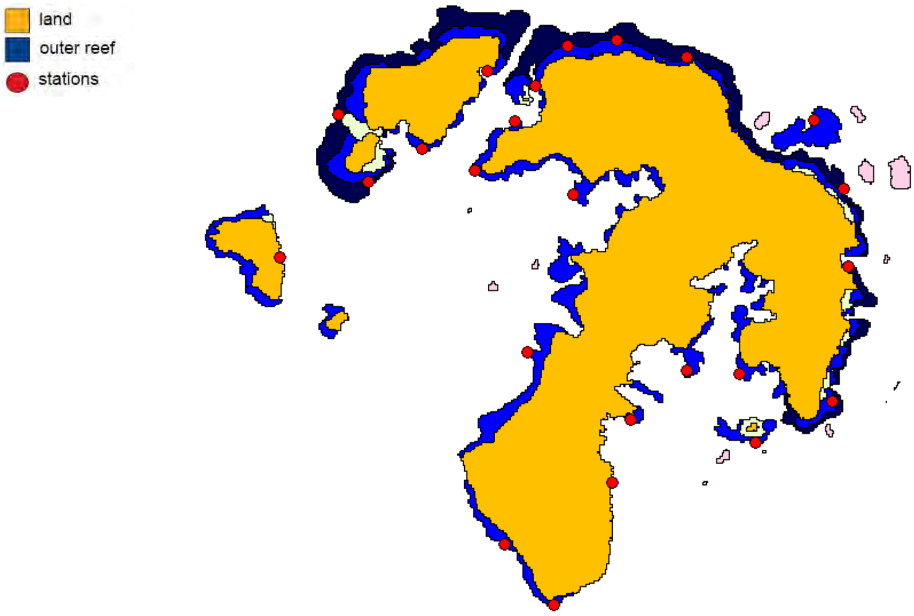

Figure 2.19: Habitat types and transect locations for finfish assessment in Nggela.

2.3.1 Finfish assessment results: Nggela

A total of 22 families, 61 genera, 190 species and 14,423 fish were recorded in the 24 transects (See Appendix 3.1.3 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 49 genera, 166 species and 11,135 individuals. Finfish resources were assessed only from the outer reefs, which were the only habitats present (Table 2.6).

Table 2.6: Primary finfish habitat and resource parameters recorded in Nggela (average values ±SE)

Parameters	Habitat Outer reef (1)
Number of transects	24
Total habitat area (km^2)	6.3
Depth (m)	7 (1–16) (2)
Soft bottom (% cover)	7 ±2
Rubble & boulders (% cover)	5 ±2
Hard bottom (% cover)	63 ±3
Live coral (% cover)	23 ±2
Soft coral (% cover)	2 ±4
Biodiversity (species/transect)	51 ±3
Density (fish/m^2)	0.8 ±0.1
Size (cm FL) (3)	20 ±0
Size ratio (%)	63 ±1
Biomass (g/m^2)	203.6 ±32.0

(1) Unweighted average; (2) depth range; (3) FL = fork length.

Outer-reef environment: Nggela

The outer-reef environment of Nggela was dominated by herbivorous Acanthuridae in terms of density and by this same family and Scaridae along with carnivores Lutjanidae and Lethrinidae in terms of biomass (Figure 2.20). These four families were represented by 65 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Acanthurus lineatus*, *Scarus psittacus*, *A. pyroferus*, *A. blochii*, *Lutjanus gibbus* and *Monotaxis grandoculis* (Table 2.7). This reef environment was mainly covered by hard bottom (63%), with a relatively high cover of live corals (23%) (Table 2.6 and Figure 2.20).

Table 2.7: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Nggela

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.13 ±0.02	11.0 ±2.1
	Acanthurus lineatus	Lined surgeonfish	0.04 ±0.01	12.9 ±5.7
	Acanthurus pyroferus	Chocolate surgeonfish	0.03 ±0.01	4.3 ±1.2
	Acanthurus blochii	Ringtail surgeonfish	0.02 ±0.01	20.8 ±9.0
Scaridae	*Scarus psittacus*	Common parrotfish	0.04 ±0.01	8.3 ±2.2
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.02 ±0.01	15.8 ±4.9
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.02 ±0.01	12.7 ±8.0

The density, size ratio and biomass of finfish in the outer reefs of Nggela were higher than at the other three coastal reefs, while size was lower only than the Marau value. Biodiversity was, however, the lowest among the four sites (Table 2.6). The trophic structure in Nggela outer reef was dominated by herbivorous species in terms of both density and biomass, especially due to the high abundance of Acanthuridae. Carnivorous species, especially Lutjanidae and Lethrinidae, were very low in abundance but were more important in terms of biomass. Size ratio, used as an indication of fishing stress on the fish population, was below 50% of the maximum recorded size for Labridae while, for most families, size were much higher than 60% of their maximum values.

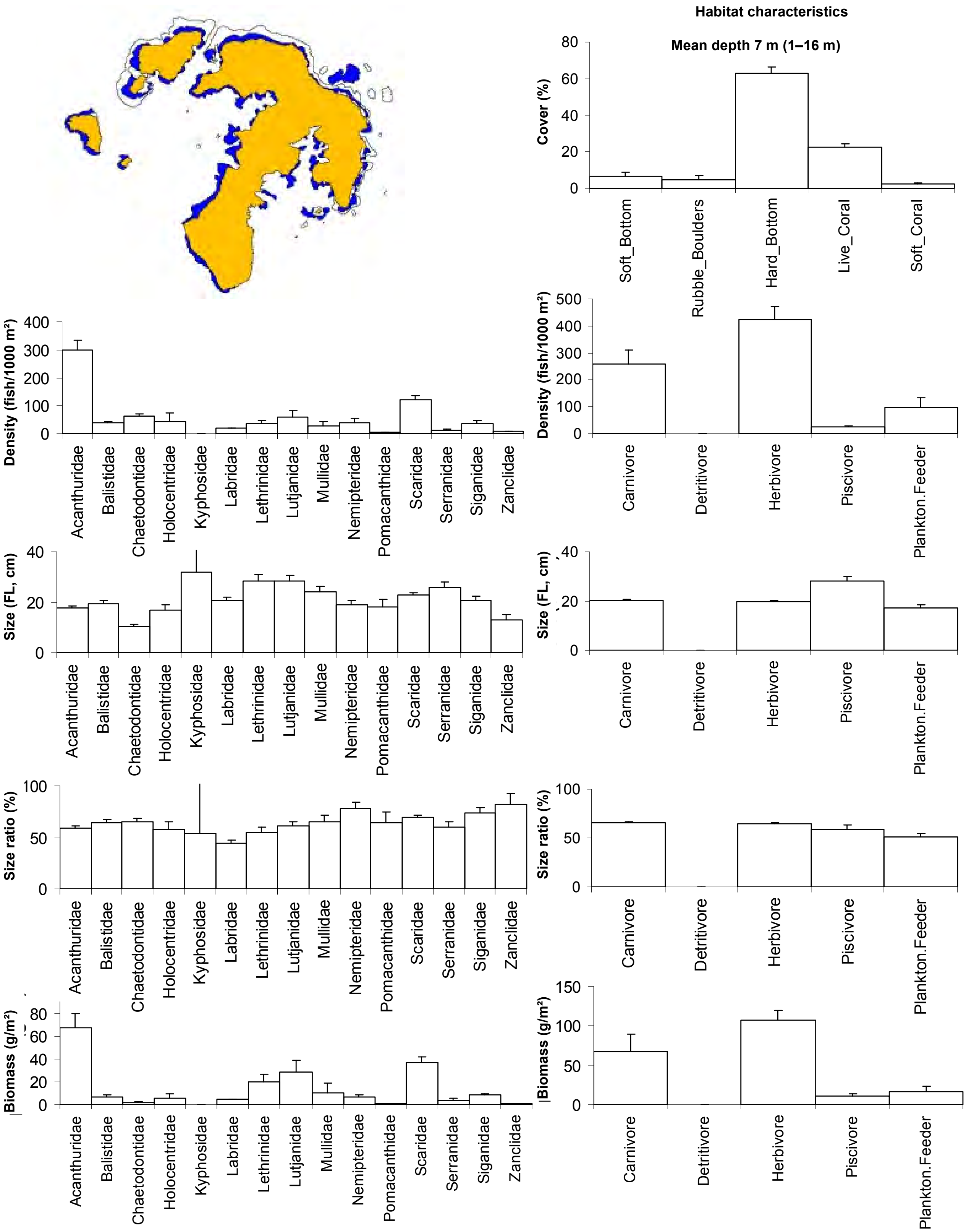

Figure 2.20: Profile of finfish resources in the outer-reef environment of Nggela.
Bars represent standard error (+SE); FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Nggela

The assessment indicated that the status of finfish resources in Nggela outer reef – the only habitat present – was higher than in the other three outer reefs in the country. Density, size ratio and biomass were all much higher than at the other sites. The trophic structure was dominated by herbivores, especially Acanthuridae, but this could be related to the high cover of hard bottom. Average size ratio per family also indicated good resource status, since almost all families recorded sizes larger than 55% of their maximum size.

- Overall, Nggela finfish resources appeared to be in relatively good condition. The reef habitat seemed relatively rich and the fish population quite healthy, although dominated by Acanthuridae.

- Nggela populations of Lethrinidae, Lutjanidae and Mullidae were important in biomass and at a similar level to the populations in Marau.

2.4 Invertebrate resource surveys: Nggela

The diversity and abundance of invertebrate species at Nggela were independently determined using a range of survey techniques (Table 2.8): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 2.21) and finer-scale assessment of specific reef and benthic habitats (Figures 2.22 and 2.23).

The main objective of the broad-scale assessment is to describe the distribution pattern of invertebrates (rareness/commonness, patchiness) at large scale and, importantly, to identify target areas for further, fine-scale assessment. Then, fine-scale assessment is conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 2.8: Number of stations and replicate measures completed at Nggela

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	13	78 transects
Soft-benthos transects (SBt)	5	30 transects
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	4	24 transects
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	0	0 search period
Reef-front search by walking (RFs_w)	0	0 search period
Sea cucumber day searches (Ds)	4	24 search periods
Sea cucumber night searches (Ns)	2	12 search periods

Figure 2.21: Broad-scale survey stations for invertebrates in Nggela.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 2.22: Fine-scale reef-benthos transect survey stations and soft-benthos transect survey stations for invertebrates in Nggela.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

Figure 2.23: Fine-scale survey stations for invertebrates in Nggela.
Inverted black triangles: reef-front search stations (RFs);
black squares: mother-of-pearl transect stations (MOPt);
grey circles: sea cucumber night search stations (Ns);
grey stars: sea cucumber day search stations (Ds).

Seventy-five species or species groups (groups of species within a genus) were recorded in the Nggela invertebrate surveys. These included 13 bivalves, 26 gastropods, 18 sea cucumbers, 7 urchins, 5 sea stars, 1 cnidarian and 2 lobsters (Appendix 4.1.1). Information on key families and species is detailed below.

2.4.1 Giant clams: Nggela

The prevailing swells in the north and dynamic water through Sandfly passage characterised the system, although the embayment north of Olevuga village was bordered by mangroves and had a muddy shoreline. Shallow-reef habitat that is suitable for giant clams was moderately limited in scale on the islands west of Sandfly passage on Nggela (3.7 km² of oceanic fringing reef and 3.5 km² of reef platform). This section of Nggela was subject to land influences in places (in the form of allochthonous inputs and nutrients), but was largely influenced by oceanic water flows. Fringing reef in the north sloped relatively gently into deeper water; however, at the less exposed areas of fringing reef between island groups, the reef dropped off more sharply.

Broad-scale sampling provided an overview of giant clam distribution on the islands west of Sandfly passage on Nggela. Reefs at Nggela held five species of giant clam: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the fluted clam *T. squamosa*, the smooth clam *T. derasa*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. The true giant clam *T. gigas* was not recorded in survey, but several (<15) aquacultured *T. gigas* (medium sizes, ~40–50 cm) were noted in front of the Maravagi Resort and one wild specimen was noted in the north by the PROCFish finfish survey team. Records from broad-scale sampling revealed that *T. maxima* had the widest occurrence (found in 9 stations and 22 transects), followed by *T. crocea* (in 8 stations and 15 transects), *T. squamosa* (in 4 stations and 5 transects) and *T. derasa* (in 1 station and 1 transect). *H. hippopus* was not recorded on broad-scale surveys. The average station density of the most common species, *T. maxima*, recorded in broad-scale surveys was low, 6.2 /ha ±1.6; see Figure 2.24).

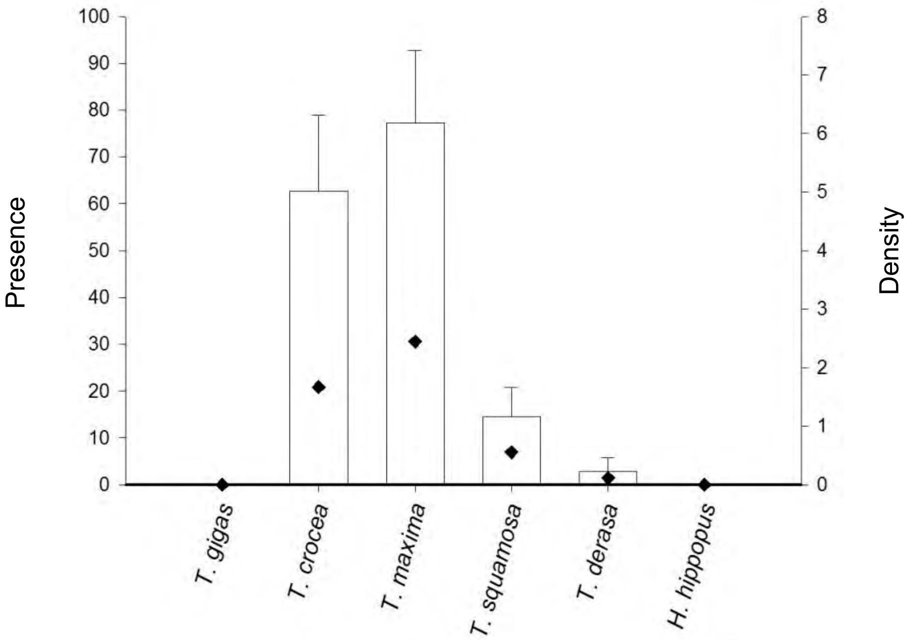

Figure 2.24: Presence and mean density of giant clam species in Nggela based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

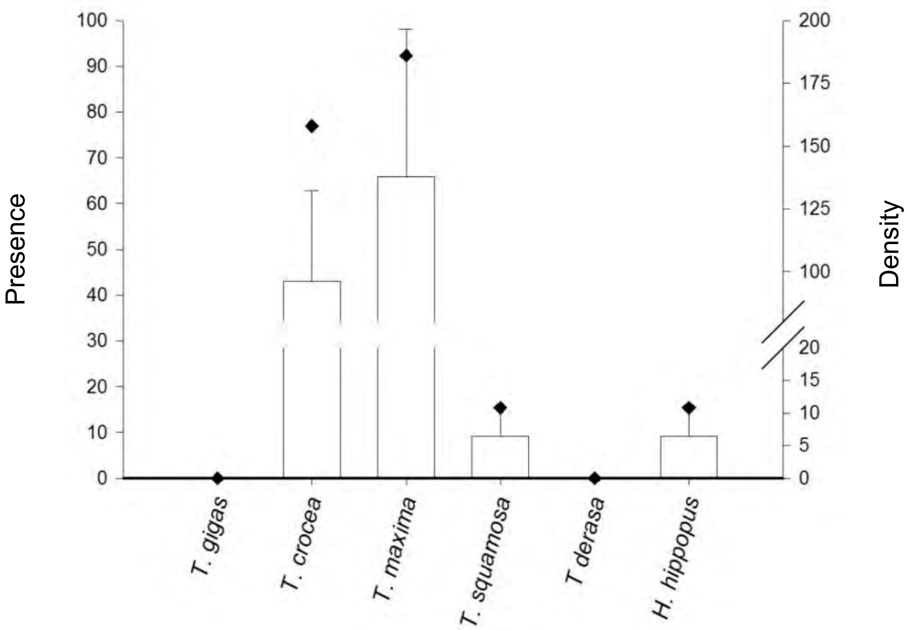

Figure 2.25: Presence and mean density of giant clam species in Nggela based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 2.25). In these reef-benthos assessments (RBt), *T. maxima* was present in 92% of stations at a mean density of 137.8 /ha ±58.8.

The density of *T. maxima* was consistent across RBt stations, with the best site being found in the southeast of Mangalonga Island. This station on reef platform was subject to water flows between Sandfly Island and Mangalonga Island, and held *T. maxima* at a station density of 833 /ha. The greatest density of clams per 40 m² transect in Nggela was 1500 /ha, which equals to 1.5 clams per 10 m². Only one station, on Soghonara Island, had no record for giant clams.

Of the 147 clam records (from all assessment methods), the average shell length of giant clams record was 14.0 cm ±0.6 for *T. maxima* (n = 82), 8.0 cm ±0.4 for *T. crocea* (n = 50) and 19.3 cm ±2.4 for *T. squamosa* (n = 9). Only two *H. hippopus* were measured (8 and 18 cm), and the four *T. derasa* measured averaged 16.7 cm ±3.5 in length.

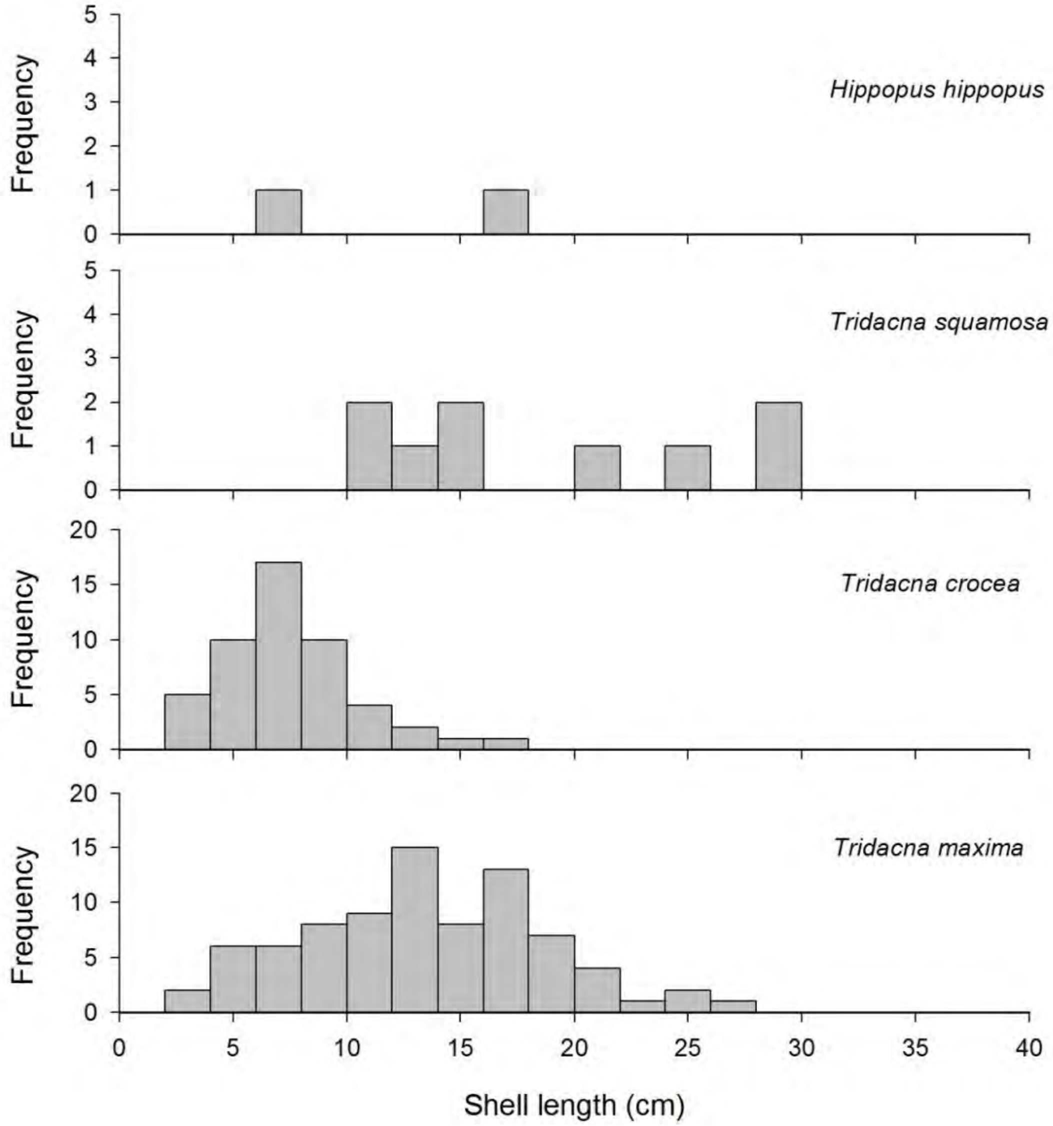

Figure 2.26: Size frequency histograms of giant clam shell length (cm) for Nggela.

2.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Nggela

The commercial topshell, *Trochus niloticus*, naturally occurs in Solomon Islands (natural distribution stops at Wallis Island to the east). Suitable reef at Nggela (6.5 km lineal distance of exposed reef perimeter) provides relatively extensive benthos for *T. niloticus*, although suitable rubble back-reef that would be used predominantly for the juvenile stage in the life cycle was not developed on these exposed fringing-reef shorelines. Nevertheless, the shorelines were subject to dynamic water movement and were suitable for this commercial species, despite the lack of offshore shoals and shallow, sloping reef fronts, which would have increased the available area for trochus.

PROCFish/C survey work revealed that *T. niloticus* was widespread across the reefs in Nggela, being present on Sandfly Island in 50% of the shallow-water reef benthos stations and three of the four mother-of-pearl transect stations along the northern reefs (Table 2.9).

Table 2.9: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Nggela
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	3.7	1.2	6/12 = 50	6/12 = 50
RBt	38.7	16.0	7/14 = 50	9/84 = 11
RFs				None completed
MOPt	57.3	19.7	3/4 = 75	7/24 = 29
Tectus pyramis				
B-S	12.5	6.5	8/12 = 67	11/72 = 15
RBt	101.2	30.8	9/14 = 64	19/84 = 23
RFs				None completed
MOPt	93.8	47.0	4/4 = 100	11/24 = 46
Pinctada margaritifera				
B-S	1.8	0.8	4/12 = 33	5/72 = 7
RBt	17.9	7.2	5/14 = 7	6/84 = 7
MOPt	10.4	6.0	2/4 = 50	2/24 = 8
Ds	0.9	0.9	1/4 = 25	1/24 = 4

B-S = broad-scale survey; RBt = reef-benthos transect; RFs = reef-front search; MOPt = mother-of-pearl transect; Ds = day search.

As the trade winds come from the southeast, most of these coastlines are protected, except during December – March, when northwest equatorial monsoon winds can affect the northerly aspect of Sandfly and Mangalonga Islands. Trochus were found at many locations on Sandfly, Mangalonga and Soghonara Islands (total n = 41 individuals), although no high-density aggregations were recorded and most stations were holding trochus at very low numbers.

Despite the suitable habitat and wide distribution of trochus, the density of this commercial species at Nggela was very low. No large aggregations were recorded, despite this broadcast spawner requiring males and females to be in close proximity (at high density) to allow successful reproduction to take place. If the fishery adopts a threshold of ~500–600 shells/ha as the minimum density required before main aggregations can be considered sufficient for commercial fishing, the trochus density records from Nggela indicate a significant shortfall in overall abundance (mean density was generally <50 /ha).

Shell size also gives an important indication of the status of stocks, by highlighting new recruitment into the fishery, or the lack of recruitment, which could have implications for the numbers of trochus entering the capture size classes in the following two years. The mean size (basal width) of trochus at Nggela was 7.1 cm ±0.4 (n = 25; see Figure 2.27.). Trochus were recorded at small sizes at Nggela despite this component of the population having a very cryptic habit. Younger shells are normally only picked up in surveys from the size of about 5.5 cm, when small trochus are emerging from a cryptic phase of life and joining the main stock. As can be seen from the length frequency graph, small trochus and early-stage adults were noted entering the capture size classes of the fishery, despite the overall low density.

Young trochus enter the fishery stock at ~8 cm, when they are ~3 years old. Typically, trochus >11 cm are common in survey recordings, as these shells are less cryptic than smaller shells and, due to their prolific spawning potential, are protected from fishing so they can contribute to future harvests (A trochus of 13 cm produces three times the number of eggs as a trochus of 10 cm.). In some well managed fisheries, shells >11 cm make up 20% of the measured stock. In Figure 2.27, a dotted line highlights the 12 cm basal size mark, when larger, mature shells would be protected from fishing under Solomon Islands regulations. It is obvious from these results, that shells are not living to reach this size due to over-fishing of legal size classes, or that trochus are being taken from the fishery even if they are over the legal size.

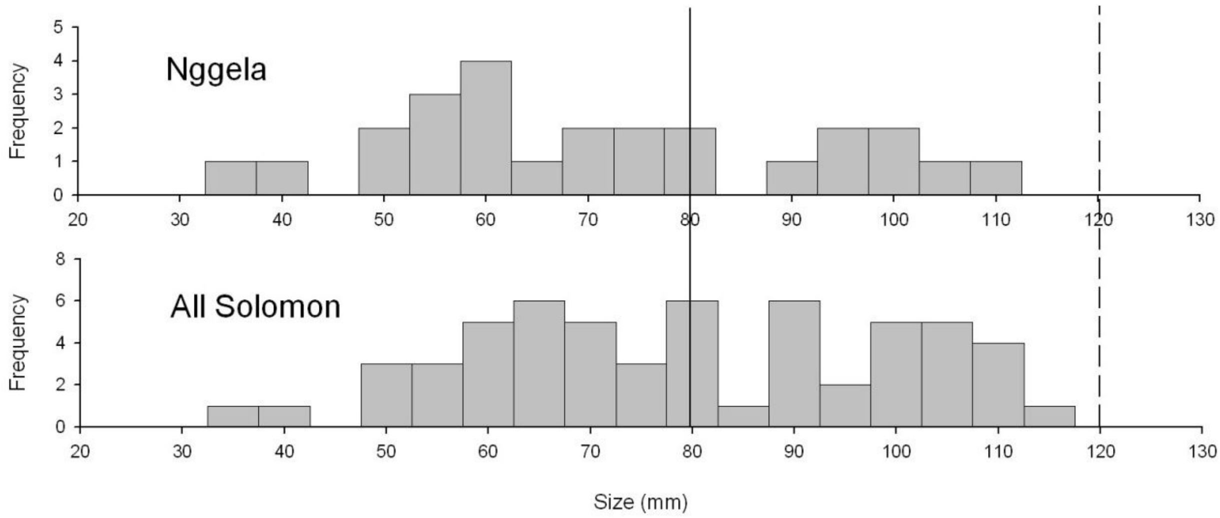

Figure 2.27: Size frequency histograms of trochus shell base diameter (cm) for Nggela.

The suitability of reefs for grazing gastropods was highlighted by results for the false trochus or green topshell (*Tectus pyramis*). This closely related species (with similar life habits) was noted at double the number of transects within shallow-water reef transect stations and at 2.6 times the density. This less valuable species of algal-grazing topshell was recorded at moderately high density (>200 /ha in 4 of the 13 RBt stations).

Despite blacklip pearl oysters, *Pinctada margaritifera*, being cryptic and normally sparsely distributed in open lagoon systems, blacklip were moderately common in surveys (n = 17). No green snail, *Turbo marmoratus*, was recorded in surveys.

2.4.3 Infaunal species and groups: Nggela

Soft-benthos areas were not common along the coastal margins of Nggela. No notable concentrations of in-ground resources (shell 'beds'), for resource species such as arc shells (*Anadara* spp.), or venus shells (*Gafrarium* spp.) were recorded and, therefore, no infaunal stations (quadrat surveys) were completed.

2.4.4 Other gastropods and bivalves: Nggela

Seba's spider conch, *Lambis truncata* (the larger of the common spider conchs) was rare in surveys (Only one individual was recorded.). *Lambis lambis* and the strawberry or red-lipped conch *Strombus luhuanus* were not very common either (recorded in 33% or less of B-S, RBt or SBt stations), reaching an average density of <30 /ha. There was, however, a large range of species present (*L. scorpius*, *L. crocata*, *L. chiragra*).

Small turban shells were recorded in survey (e.g. *Turbo argyrostomus*, *T. chrysostomus* and *T. petholatus*), although the more sought-after *T. setosus* was absent and *T. argyrostomus* was not recorded in shallow-reef stations and was rare in MOPt stations (mean density 2.6 /ha ±2.6). Other resource species targeted by fishers (e.g. *Astralium*, *Cassis*, *Cerithium*, *Chicoreus*, *Conus*, *Cymatium*, *Cypraea*, *Oliva*, *Pleuroploca*, *Thais* and *Vasum*) were also recorded during independent surveys (Appendices 4.1.1 to 4.1.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa*, *Pinna*, *Pteria* and *Spondylus* are also in Appendices 4.1.1 to 4.1.7. No creel survey was conducted at Nggela.

2.4.5 Lobsters: Nggela

Nggela had 6.5 km (lineal distance) of exposed fringing reef. This exposed reef provided a suitable habitat for lobsters. Lobsters are an unusual invertebrate species, which can recruit from near and distant reefs as their larvae drift in the ocean for 6–12 months (up to 22 months) before settling as transparent miniature versions of the adult (pueruli, 20–30 mm in length).

There was no dedicated night reef-front assessment of lobsters (See Methods.) but, nevertheless, surveys still recorded seventeen *Panulirus* sp., one sand lobster, and the banded prawn killer *Lysiosquillina maculata*. Although no slipper lobsters were noted, the mud lobster, *Thalassina* sp., was recorded.

2.4.6 Sea cucumbers[8]: Nggela

Sandfly Island is a moderately extensive land mass (26.5 km²), but has a limited area of protected shallow water with reef margins and areas of shallow, mixed, hard- and soft-benthos habitat that are suitable for sea cucumbers (Most sea cucumbers are deposit feeders, which eat organic matter in the upper few mm of bottom substrates.). There was significant land and riverine influence close to shore, but the predominant influence was oceanic, with dynamic water movement and flushing. The benthos was generally without heavy epiphytic

[8] There has been a recent variation to sea cucumber taxonomy which has changed the name of the black teatfish in the Pacific from *Holothuria (Microthele) nobilis* to *H. whitmaei*. There is also the possibility of a future change in the white teatfish name. This should be noted when comparing texts, as in this report the 'original' taxonomic names are used.

growth. In some areas, the land influence was more notable, especially near the mangroves next to Olevuga village, and in some areas on the northern reef. Outside the fringing reef, the benthos shelved relatively steeply, without the presence of large areas of shallow reef (shoals) located offshore.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.10, Appendices 4.1.2 to 4.1.9; also see Methods.). At Nggela, 17 commercial species of sea cucumber were recorded during in-water assessments, plus one indicator species (Table 2.10). The range of sea cucumber species recorded in Nggela somewhat reflected the position of Solomon Islands, which is close to the centre of biodiversity. However, here, the range of habitats was not as varied as in other parts of Solomon Islands.

Sea cucumber species associated with shallow-reef areas, such as leopardfish (*Bohadschia argus*) were not common in broad-scale surveys (recorded in 4% of transects). Average density records for this species, at <1 /ha in B-S and <12 /ha in RBt stations, suggest that stocks are at very low densities. Black teatfish (*Holothuria nobilis*) is a high-value species that is highly susceptible to over-fishing, and therefore provides a good indicator of fishing pressure when the distribution and density is known. This species was rare in general surveys (only recorded in 1% of broad-scale transects), and was not recorded in other surveys except in night searches. This species is unlikely to be at such a low presence and density because of environmental drivers, as the site had suitable habitat. This suggests that fishing pressure has depleted stocks.

Notably, the fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was not found at any stations in Nggela. Surf redfish (*Actinopyga mauritiana*), another easily targeted species, was rare at Nggela and at average densities of <10 /ha when found. The highest-density areas of surf redfish were recorded in shallow-reef assessments on Soghonara Island, and even here the average station density did not exceed 100 /ha. This species can be recorded at commercial densities in excess of 500–600 /ha in parts of Guadalcanal, and also in Cook Islands, French Polynesia and Tonga.

In more protected areas of fringing reef and soft benthos, in areas that were less dynamic, we did not find blackfish (*Actinopyga miliaris*), and curryfish (*S. hermanni*) were rare. Even low-value lollyfish (*Holothuria atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*) were uncommon and at low density.

An exception to these disappointing results was the presence of the premium-value sandfish (*H. scabra*) which was recorded at low density (average 19.9 /ha) in two of the five soft benthos transect stations surveyed (n = 3, average length 14.5 cm).

Deeper-water assessments (24 five-minute searches, average depth 23.5 m, maximum depth 30 m) were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), amberfish (*T. anax*) and partially for elephant trunkfish (*H. fuscopunctata*). Four stations of oceanic-influenced benthos along longshore reef drop-offs, where there was suitably dynamic water movement, were checked and *H. fuscogilva* were recorded in all stations. White teatfish were moderately common (average density 17.8 /ha, n = 20) at the stations surveyed. Unlike in the more protected areas of Marau, no white teatfish records were made in shallower water. The lower-value and generally more common amberfish (*T. anax*) was not common in survey.

2.4.7 Other echinoderms: Nggela

The edible collector urchin (*Tripneustes gratilla*) was recorded in a number of different survey types at low density. Slate urchins (*Heterocentrotus mammillatus* and *H. trigonarius*) were uncommon, but the large, black *Echinothrix* sp. (also edible and a habitat indicator species) were both common (42% of B-S and 62% of RBt stations) and at high density in patches (up to 2083 /ha in B-S stations and 10,750 /ha in RBt stations). *Echinometra mathaei* and *Diadema* spp. were also commonly noted (Appendices 4.1.1 to 4.1.7).

Starfish were common around Nggela; the common blue and yellow starfish (*Linckia laevigata* and *L. guildingi*) were recorded in large numbers (n = 802) and were common across broad-scale surveys (100% of B-S stations). Pincushion stars (*Culcita novaeguineae*) were also commonly recorded (in 75% of B-S stations), but were not at high density (4.8 /ha ±2.4). Another, more serious threat to corals (coralivore, coral-eating starfish), was the crown of thorns star (*Acanthaster planci*, COTS) which was present in large numbers (n = 341).

The distribution of COTS was widespread around the reefs in Nggela (recorded in 100% of B-S stations and 39% of transects). The density of COTS showed local areas of concentration, with 9.7% of broad-scale transects recording >100 COTS /ha (Figure 2.28).

These density estimates are likely to be conservative, as COTS are not active during the day when broad-scale surveys were conducted. This level of colonisation can be considered as an 'active outbreak' in some of the areas sampled, as Australian scientists working on the Great Barrier Reef define an 'active outbreak' as >1.0 adults per 2-minute manta tow or >30 adult only starfish per ha if SCUBA diving. Adults are defined as >15 cm in diameter. PROCFish broad-scale transects of 300 m x 2 m swathe take about 8 minutes to complete, and therefore recordings of >4 COTS /transect would be sufficient to qualify for such a classification. In the PROCFish data for Nggela, 15% of transects qualified for an 'active outbreak' label. Note: There was an FSPI village conservation officer based on Sandfly Island who was responsible for removing COTS from local reefs and putting them onshore.

This is of concern as COTS can consume significant amounts of live coral (2–6 m² of coral per year). On the Great Barrier Reef, an 'incipient outbreak' is defined as the density at which coral damage is likely when there are 0.22 adults per 2-minute manta tow; or >30 adult and subadults per ha. In the case of the PROCFish data, 39% of transects qualify for this definition.

Figure 2.28: Average density of COTS recorded in broad-scale assessment stations at Nggela.
The circles highlight broad-scale station densities ranging from a mean of 3–163 /ha.

Table 2.10: Sea cucumber species records for Nggela

Species	Common name	Commercial value [5]	B-S transects n = 72			Reef-benthos stations n = 13			Other stations SBt = 5; MOPt = 4			Other stations Ds = 4 ;Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H				3.2	41.7	8						
Actinopyga mauritiana	Surf redfish	M/H	0.2	16.7	1	6.4	83.3	8	5.2	20.8	25 MOPt			
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	0.7	16.7	4	12.8	83.3	15	5.2	20.8	25 MOPt	0.9	3.6	25 Ds
Bohadschia graeffei	Flowerfish	L	3.2	33.3	10				5.2	20.8	25 MOPt			
Bohadschia similis	False sandfish	L							25.0	62.5	40 SBt			
Bohadschia vitiensis	Brown sandfish	L										8.9	17.8	50 Ns
Holothuria atra	Lollyfish	L	2.8	20.0	14	28.8	62.5	46	15.6	20.8	75 MOPt	5.4	7.1	75 Ds
Holothuria coluber	Snakefish	L							8.3	41.7	20 SBt	22.2	44.4	50 Ns
Holothuria edulis	Pinkfish	L				3.2	41.7	8				2.7	5.4	50 Ds
Holothuria fuscogilva [4]	White teatfish	H										17.8	17.8	100 Ds
Holothuria fuscopunctata	Elephant trunkfish	M				3.2	41.7	8				1.8	3.6	50 Ds
Holothuria nobilis [4]	Black teatfish	H	0.2	16.7	1							4.4	8.9	50 Ns
Holothuria scabra	Sandfish	H							25.0	62.5	40 SBt			
Stichopus chloronotus	Greenfish	H/M												
Stichopus hermanni	Curryfish	H/M	0.2	16.7	1									
Stichopus horrens	Peanutfish	M/L										13.3	26.7	50 Ns
Stichopus vastus	Brown curryfish	H/M												
Synapta spp.	-	-							91.7	458.3	20 SBt			
Thelenota ananas	Prickly redfish	H	0.7	16.7	4									
Thelenota anax	Amberfish	M	0.2	16.7	1	3.2	41.7	8				0.9	3.6	20

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) *nobilis* to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published. [5] L = low value; M = medium value; H= high value; H/M is higher in value than M/H; B-S transects= broad-scale transects; SBt = soft-benthos transects; MOPt = mother-of-pearl transects; Ds = sea cucumber day search; Ns = sea cucumber night search.

2.4.8 Discussion and conclusions: invertebrate resources in Nggela

A summary of environmental, stock-status and management factors for the main fisheries is given below. Please note that information on other, smaller fisheries and the status of less prominent species groups can be found in the body of the invertebrate chapter.

In summary, habitat, clam distribution, density and shell length information revealed that:

- Shallow-water reef was not extensive at Nggela, and was limited to narrow areas of fringing reef.

- The exposed fringing reef at Nggela, with its simple, non-varied structure and dynamic water movement, was not very suitable for the full range of giant clams that are found in Solomon Islands.

- Giant clam presence and density was in general moderate considering the nature of the environment. The elongate clam, *Tridacna maxima*, had the highest density but its distribution and aggregations were unremarkable. In addition, the other species present at Nggela were also relatively rare and at lower-than-expected densities. *Hippopus hippopus* clams were not common, mainly due to the type of environment present, but *T. squamosa* and *T. derasa* were critically depleted, as in many other parts of the Pacific, and *T. gigas* was 'commercially extinct'[9].

- Although *T. maxima*, *T. crocea* and *T. squamosa* displayed a relatively 'full' range of size classes, including young clams (which indicate successful spawning and recruitment), the low abundance of clams and sparsity of large sizes suggest that clams are heavily impacted by fishing.

- Clams are especially easy to over-fish in 'open', exposed reef systems, such as around the fringing reefs of Sandfly Island, as pelagic larvae can get carried away from their natal reefs.

Data on MOP distribution, density and shell size suggest that:

- Local reef conditions at Nggela constitute a relatively extensive and good habitat for adult trochus, although the width of the narrow reefs was somewhat limited. The area of rubble-covered back-reef, which is suitable for juvenile trochus, was less extensive.

- Trochus were widely distributed across reefs around Nggela that were easily accessible by fishers. No high-density aggregations of trochus were identified in survey.

- Most eggs are produced by the largest individuals of the population. This survey shows that this part of the population is currently depleted. Trochus reach the larger size classes (>11 cm basal width) at ≥6 years of age (from shells that would need to survive at least three years in the fishery under the current management scenario). The lack of large, older shells, which have the greatest potential to fuel future populations to support the fishery,

[9] 'Commercially extinct' means in this context that the clams were at such a low density as to make them unavailable for any trade and in danger of complete local extinction.

means that it may take five or more years for stocks to recover to a state where they are again productive.

- Size-class information reveals that recruitment is still occurring, even though previous harvests have comprehensively impacted stock density in most areas.

- There is presently no scope for commercial trochus fishing at Nggela, as densities of stocks are well below any recommended threshold where managers should consider fishing. Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha.

- The low commercial value green topshell, *Tectus pyramis*, and blacklip pearl oyster, *Pinctada margaritifera*, were relatively common at Nggela.

- The green snail (*Turbo marmoratus*) a native species commonly found in Nggela during previous surveys, was not noted in this survey. This species is considered commercially extinct in Nggela.

In summary, the distribution, density and length recordings of sea cucumbers at Nggela reveal that:

- Although commercial sea cucumber species at Nggela were numerous (n = 17), reflecting the biogeographical position of the site, the range of sea cucumbers present was somewhat limited by the more exposed nature of habitats present.

- Distribution data showed that sea cucumbers were well spread across the site, although medium- and high-value commercial species, such as the leopard or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*) were not common. Unusually, low-value species, such as lollyfish (*H. atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*) were also only recorded at relatively low density.

- The low density of most sea cucumber species and species groups suggests that there is little potential for further harvesting at this time.

- The oceanic nature of the area and its dynamic water movement suited the high-value, deeper-water white teatfish (*H. fuscogilva*). This species was moderately common in Nggela; with careful management of harvests, a small regular harvest of this species is possible from deeper-water areas around Nggela.

2.5 Overall recommendations for Nggela

- Community fisheries management projects need to be continued and improved, with a precautionary approach to resource use. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures for specific invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Nggela fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- Pressure on finfish resources is already extremely high and high also on at least a number of invertebrate species. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

- Cooperation among governmental, NGOs and other external institutions, and the Nggela community needs to be fostered in order to ensure the success of improved fisheries management.

- For successful stock management, giant clams need to be maintained at higher density and include larger-sized individuals, to ensure there is sufficient spawning taking place to produce new generations.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha.

- Management arrangements need to be developed and implemented for sea cucumbers given the low densities of most species.

3. PROFILE AND RESULTS FOR MARAU

3.1 Site characteristics

Marau is located in Guadalcanal Province (Figure 3.1). Marau Sound is a large lagoon at the eastern tip of Guadalcanal with fringing reefs around clusters of islands. Marau Sound and part of the north-west coast are the only areas with sea-level reef flats on Guadalcanal. Marau itself is enclosed by a crescent-shaped, partially drowned reef. In Marau, the islands which are located close to the mainland were surrounded by thick mangrove forests with intermittent patches of narrow reef flats (<20 m wide) at their fringes. Islands further out, facing the open ocean, tend to have wider reef flats reaching 0.5 km in some areas. There is a high rate of water exchange through the inlets resulting in permanent clear waters inside the Sound. There is high coral diversity and healthy coral growth; however, live coral cover was low-to-moderate. Moderate-to-high infestation of crown-of-thorn starfish was observed in a number of reefs in Marau.

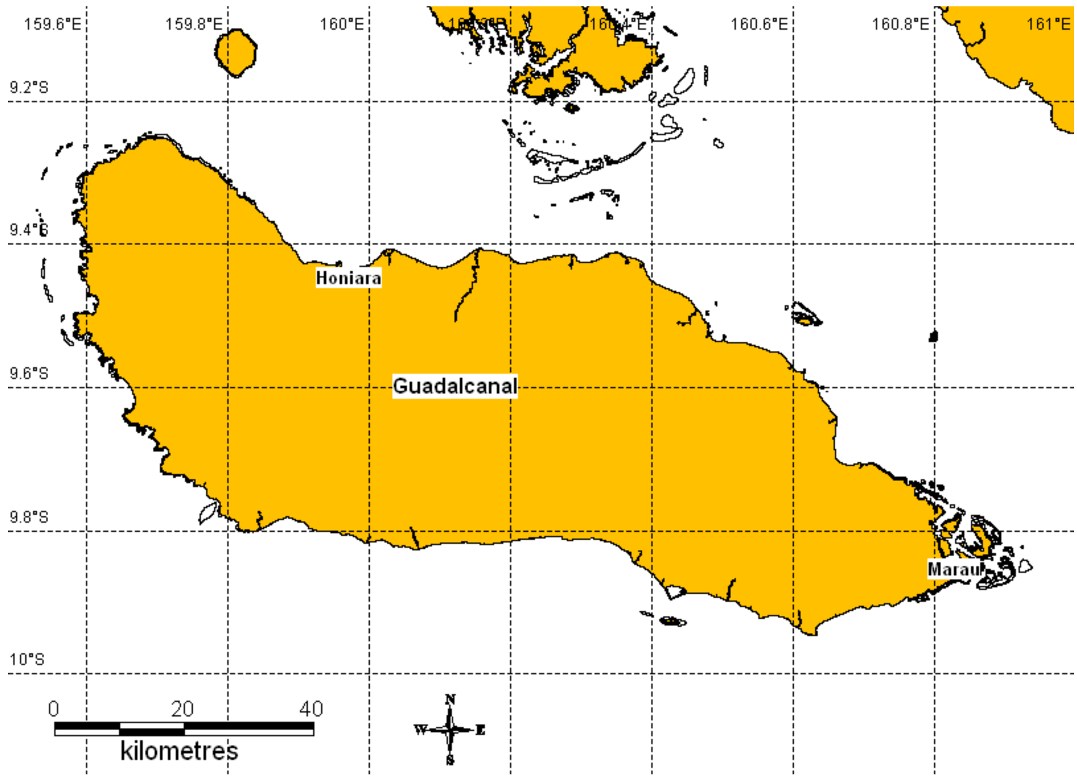

Figure 3.1: Map of Marau.

3.2 Socioeconomic surveys: Marau

Socioeconomic fieldwork was carried out on the island of Marau, located in the Guadalcanal Province of the Solomon Islands on 21 June – 3 July 2006. The survey included three smaller islands in the Marau area, a number of villages on the mainland, and the two small islands of Niu and Tawaihi. The community surveyed, referred to as 'Marau' in the following, included a total population of 2244. In total, 50 households or about 17% of the total (300) households within the community were surveyed. All (100%) of these households are engaged in some form of fishing activities. In addition, a total of 71 finfish fishers (51 males and 20 females) and 30 invertebrate fishers (16 males and 14 females) were interviewed. The average household size is 7 people; however, most people live in extended family groupings and village life is mostly organised around major clans or dominant family groups. Household interviews focused on the collection of general demographic, socioeconomic and consumption data.

Although Marau people have access to considerable agricultural land areas on the mainland, income-earning opportunities are very limited. Firstly, the population has increased since 2000, when ethnic tension resulted in the resettlement of Malaitan people in the area. Also, the government installation of a fishing centre in Marau was destroyed and, as a result, income-earning activities associated with marketing have changed in the last 6–8 years. Honiara is the single major market remaining in the area. Because of the high transport costs to reach Honiara either by boat or plane, marketing of fishery produce is organised through middlemen and agents, who come on a fortnightly basis to the villages (according to the frequency of the inter-island vessel) and who usually buy two ice boxes full of reef fish, which they sell at Honiara. This system does not only apply to Marau but to all rural coastal areas. This results in an oversupply of fish, reduced prices and limits on the catch volume to be sold. While this is definitely a positive regulation in that it prevents overuse of marine resources, it also limits the livelihood of people in the area.

Sales of fishery or other produce by individuals are very limited due to the cost and time required to go by boat to Honiara, or to use the inter-island vessel without having access to proper cooling or ice blocks, and due to the lack of the availability and irregularity of small-plane transport. At the time of the survey there were only seven motorised boats in the community, compared to at least 70 non-motorised canoes.

Very little reef fish is sold locally, either at the fortnightly local market, or to the few nearby tourist resorts. This is because catch is distributed among community members on a non-monetary basis or provided for social and religious functions on a regular basis.

Since the temporary ban on bêche-de-mer harvesting, fishers in Marau have focused on harvesting wild species for the aquarium trade, mainly live corals. Some fishers are also involved in the cultured corals' production in Marau Sound. However, the expected income from any of these activities is limited, i.e. about SBD 7800 /year for wild coral harvesting and SBD 1340 in the cultured coral business. Traders for these products are mainly based in Honiara, and the people of Niu are mostly engaged. In addition, trochus shells are sold about once a month to buyers arriving on the island. The price was reported to be SBD 18 /kg at the time of the survey.

Typically, a middleman from Honiara informs the community of his visit day, purchases ice from Honiara (SBD 4 /kg; a block of ice costs SBD 45,000 and 3 blocks are needed for each of the two ice boxes to be filled) and purchases a fortnightly order worth SBD 8000, corresponding to about 800–900 kg. While fish is bought for SBD 6 /kg from fishers, it is sold for SBD 9 /kg at the Honiara market. Consumers still prefer reef fish; however, pelagic species are also marketed. Because this system involves a number of middlemen, most of which are in the business at least for 6–7 years, there is a considerable oversupply from fishers, and also at the Honiara market. The lack of a cold chain, if ice is used at all, and fish that has not been properly cleaned, add to problems in supplying good quality fish and result in a high rate of spoilage. Selling at Honiara is mostly done directly from the ice boxes. Some of the middlemen have females selling their produce for them at the Honiara market. The lack of proper preservation methods was observed and considered as a major reason for the spoilage of catch. Sometimes, middlemen supply fishers with hooks and lines and deduct the cost of these from their revenues. Also fishers need to pay, using part of their catch, for the use of their canoes or motorised boats.

Small income opportunities occur at the fortnightly local markets where agricultural and fisheries produce is offered and sold.

In addition, there are some middlemen in Marau and commercial fishers who sell certain catch directly upon demand to clients in Honiara. This applies in particular for special species, such as lobsters. For instance, there are fishers who may hire a group of other fishers to collect lobsters to fill a placed order. The catch is then put on a plane to Honiara, and all fishers involved are paid.

3.2.1 The role of fisheries in the Marau community: fishery demographics, income and seafood consumption patterns

Our results (Figure 3.2) suggest that the primary sector provides the most important income opportunities for the people of Marau. Fisheries take the leading role, with 46% of all households earning first income from fisheries and another 30% second income. Agriculture provides 28% of all households with first cash income and 36% with second income. Salaries, mostly in the logging industry, or other sources, such as handicrafts, wood carving and small business (betel nut and lime selling) are less important, providing 10% and 16% of households respectively with first source of revenues. Almost 40% of all households have one or two pigs and almost 40% also have a couple of chickens for home consumption purposes.

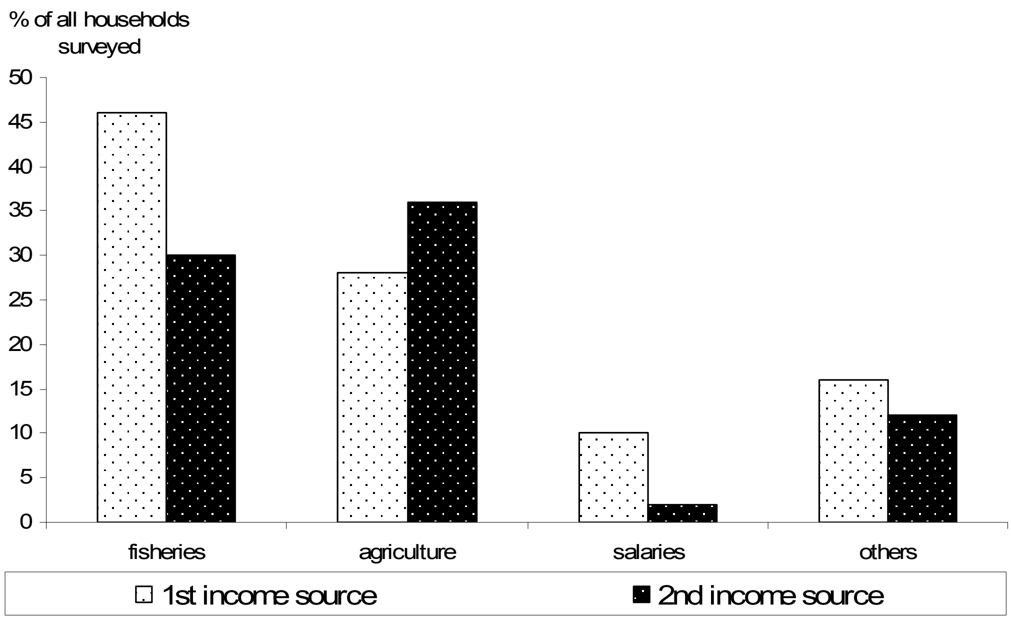

Figure 3.2: Ranked sources of income (%) in Marau.
Total number of households = 50 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly home-based small business.

Our results (Table 3.1) show that annual household expenditures are low with an average of USD 425. However, compared with the other sites surveyed in Solomon Islands, Marau is one of the communities with higher expenditures and thus better access to cash income opportunities. Remittance is not an important component of Marau's household income, with 12% of households receiving remittances at an average rate of USD ~163 /year only. Remittances are mostly money sent from family members living and working in Honiara.

Table 3.1: Fishery demography, income and seafood consumption patterns in Marau

Survey coverage	Site (n = 50 HH)	Average across sites (n = 182 HH)
Demography		
HH involved in reef fisheries (%)	100.0	99.5
Number of fishers per HH	3.72 (±0.26)	3.24 (±0.12)
Male finfish fishers per HH (%)	15.6	17.0
Female finfish fishers per HH (%)	0.0	2.2
Male invertebrate fishers per HH (%)	0.0	0.2
Female invertebrate fishers per HH (%)	5.9	9.0
Male finfish and invertebrate fishers per HH (%)	42.5	39.6
Female finfish and invertebrate fishers per HH (%)	36.0	32.1
Income		
HH with fisheries as 1st income (%)	46.0	30.2
HH with fisheries as 2nd income (%)	30.0	32.4
HH with agriculture as 1st income (%)	28.0	33.5
HH with agriculture as 2nd income (%)	36.0	31.9
HH with salary as 1st income (%)	10.0	11.0
HH with salary as 2nd income (%)	2.0	0.5
HH with other source as 1st income (%)	16.0	24.2
HH with other source as 2nd income (%)	12.0	12.1
Expenditure (USD/year/HH)	424.74 (±43.38)	404.22 (±22.58)
Remittance (USD/year/HH) (1)	162.60 (±53.29)	258.35 (±55.85)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	101.77 (±7.48)	104.78 (±4.00)
Frequency fresh fish consumed (times/week)	3.73 (±0.10)	3.57 (±0.05)
Quantity fresh invertebrate consumed (kg/capita/year)	7.33 (±1.33)	10.13 (±4.00)
Frequency fresh invertebrate consumed (times/week)	1.27 (±0.13)	1.20 (±0.06)
Quantity canned fish consumed (kg/capita/year)	3.24 (±0.76)	3.75 (±0.34)
Frequency canned fish consumed (times/week)	0.68 (±0.15)	0.85 (±0.07)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	98.0	95.6
HH eat canned fish (%)	64.0	75.3
HH eat fresh fish they catch (%)	100.0	97.6
HH eat fresh fish they buy (%)	22.0	21.4
HH eat fresh fish they are given (%)	50.0	71.4
HH eat fresh invertebrates they catch (%)	100.0	71.4
HH eat fresh invertebrates they buy (%)	2.0	0.0
HH eat fresh invertebrates they are given (%)	38.0	47.6

HH = household; (1) average sum for households that receive remittances; numbers in brackets are standard error.

Survey results indicate an average of ~4 fishers per household and, when extrapolated, the total number of fishers in Marau is 1116 including 648 males and 468 females. Among these are 174 exclusive finfish fishers (males only), 66 exclusive invertebrate fishers (females only), and 876 fishers that do both finfish fishing and invertebrate collection (474 males, 402 females). Most (~88%) households own a boat; most (~87%) are non-motorised canoes, only ~13% are equipped with an outboard engine.

Consumption of fresh fish is high at ~102 kg/person/year, a figure that is comparative to the average across all four study sites in Solomon Islands, but significantly higher than the assumed average for Solomon Islands of 40 kg (Gillet and Lightfoot 2001) and 45.5 kg/person/year (FAO 2008), or the regional average of ~35 kg/person/year (Figure 3.3). By comparison, consumption of invertebrates (edible meat weight only) (Figure 3.4) is low-to-moderate (7.3 kg/person/year). The ethnic mixture of people in the Marau community may account for the fact that community members varied substantially in their consumption of invertebrates. For instance, octopus, lobsters and turtles are not eaten by certain community groups. Canned fish (Table 3.1) adds only 3.2 kg/person/year to the protein supply from seafood. The consumption pattern of seafood found in Marau highlights the fact that people have access to agricultural and fishery resources. People produce enough crops and catch enough fish to be self-sufficient in food. Frozen or other imported food is hardly ever consumed due to the lack of transport, transport costs, lack of electricity and icing facilities, as well as the lack of cash. Marketing of agricultural and fishery produce is done at the Honiara market, a 4-hour boat trip by motorised boat, and more than 9 hours if using the inter-island ferry. There is also air transport, but this mostly services small tourist groups (e.g. the resort on Tawaihi), and is highly irregular. Transport costs are high, regardless of which type is chosen, and easily account for half of the potential revenues. Thus Marau people have limited access to the capital city's urban market, which explains their rural and traditional lifestyle, with limited cash revenue and low average annual household expenditure level.

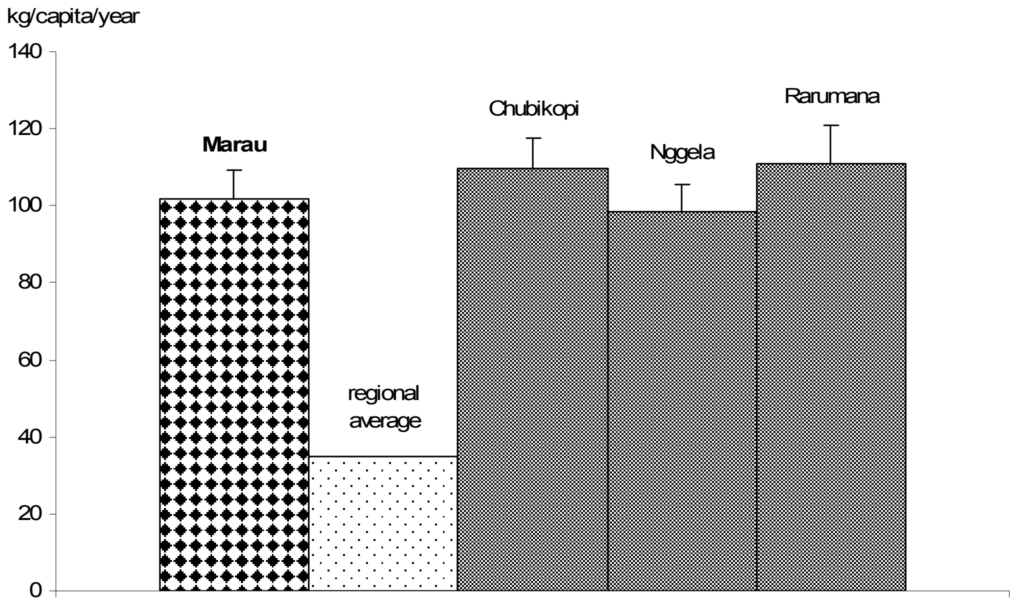

Figure 3.3: Per capita consumption (kg/year) of fresh fish in Marau (n = 50) compared to the regional average (FAO 2008) and other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

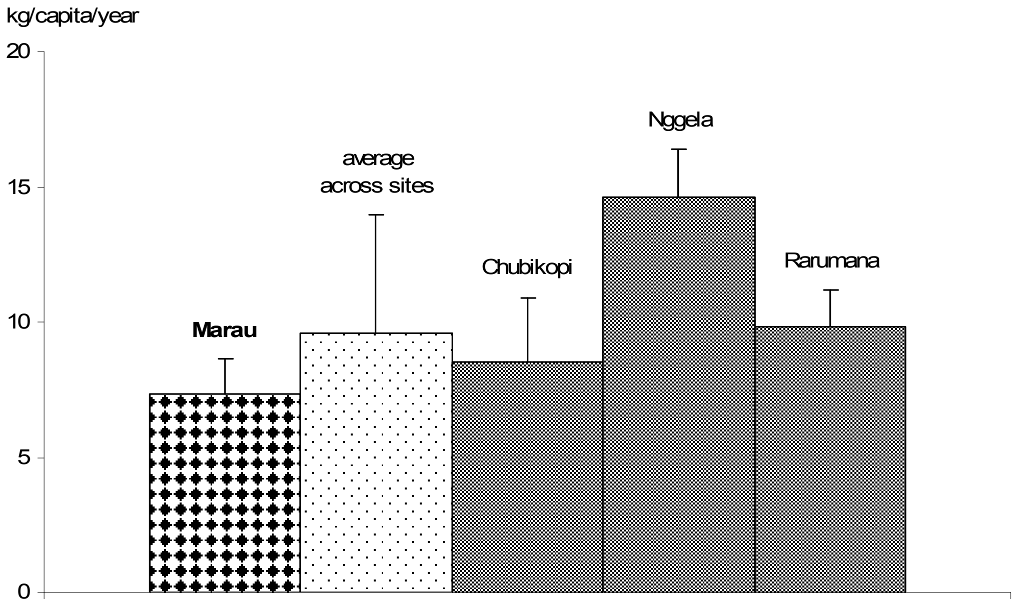

Figure 3.4: Per capita consumption (kg/year) of invertebrates (meat only) in Marau (n = 50) compared to the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results obtained for Marau to the average figures across all four study sites surveyed in Solomon Islands, people of the Marau community eat about as much fresh fish, invertebrates and canned fish as found on average but less invertebrates and canned fish. In terms of the proportion of fish and invertebrates that they consume and that they buy, or that is caught by somebody living in the household, the Marau community is the same as average. Although sharing seafood among community members on a non-monetary basis is very common, it is less practised than average across all sites. Income from fisheries plays a much greater role in generating first income than across all Solomon Islands PROCFish sites, and agriculture and other, private business or handicraft activities, a lesser role. Household expenditure level is similar but remittances received lower. By comparison, boat ownership and the dominance of non-motorised canoes does not vary much from in the other sites surveyed in Solomon Islands.

3.2.2 Fishing strategies and gear: Marau

Degree of specialisation in fishing

A couple of fisheries management interventions have already been initiated or carried out. Particularly, FSPI is heavily engaged in working with the Marau community in setting up marine protected areas and in enforcing and supporting community management measures. The government ban on bêche-de-mer harvesting applies; however, people collect live coral for the aquarium trade and harvest trochus according to the size limits set by the government. In addition, there are a number of traditional *tabu* and community-based management measures, including restrictions on females participating in certain fishing activities or areas.

Fishing is not only the most important income source; it is also the most important source of protein and calories. Fisheries produce is also important for social coherence as it is regularly exchanged among community members as a gift. There are no explicit traditional gender roles, but females are restricted from certain fishing activities, and are not allowed to fish in particular areas or to join canoes or fishing parties during menstruation. The traditional system of the Marau community has changed since the settlement of people from Malaita, who were the target of burning during the ethnic tension in 2000. This change is visible in the scattered arrangement of housing rather than coherent village structures.

However, there was a split between male and female fishers' engagement in fisheries, as found elsewhere in the Pacific, with only males exclusively fishing for finfish, and only females exclusively fishing for invertebrates. Nevertheless, most fishers, male and female, do both invertebrate harvesting and finfish fishing (Figure 3.5). Also, children participate in subsistence fisheries on a regular basis, mostly during school holidays and weekends; while accompanying their parents they learn traditional skills and knowledge.

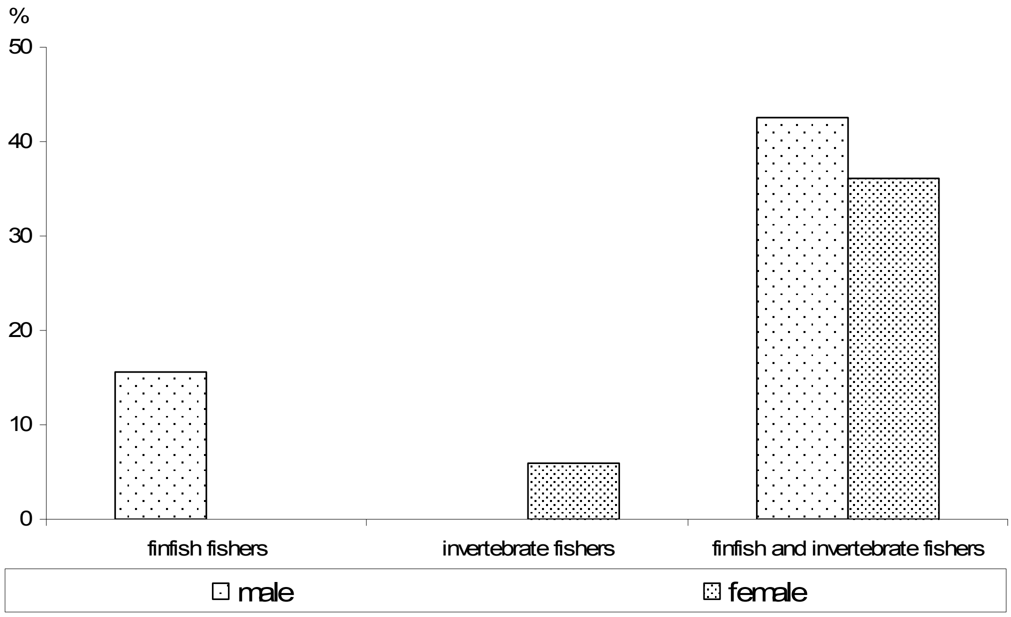

Figure 3.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Marau.
All fishers = 100%.

Targeted stocks/habitat

Boats, here mainly non-motorised canoes, are essential for transport, fishing and gardening. This is particularly true for Marau, where most people have gardens on the mainland. Most of the fishing is done in the coastal areas and lagoon (~68% of all male and 90% of female fishers). If the outer reef is targeted, travel time is longer, exposure to sea and weather conditions is higher and only males (53%) target these habitats. Table 3.2 shows that the community has access to a great number of habitats that support a great variety of invertebrates. Interviews showed that invertebrate collection serves both home-consumption and income needs and therefore targets a wide range of species and habitats. Usually fishers visit a combination of several habitats during one fishing trip. The reeftop fishery and the dive fishery for giant clams and other species attract most male fishers (~63%) and over half of all females, followed by soft-benthos and mangrove gleaning, which attracts most females (86%) and about one-third of all males. Specialised commercial invertebrate fisheries, such as trochus and lobster harvesting, only includes 12–13% of all male fishers. Low participation in an income-earning fishery may suggest a low resource status and thus low productivity and profitability.

Table 3.2: Proportion (%) of interviewed male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Marau

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	3.9	10.0
	Sheltered coastal reef & lagoon	64.7	80.0
	Sheltered coastal reef & outer reef	0.0	5.0
	Lagoon & outer reef	7.8	5.0
	Outer reef	52.9	0.0
Invertebrates	Reeftop & other	62.5	57.1
	Reeftop & trochus & other	12.5	0.0
	Intertidal & reeftop	0.0	14.3
	Intertidal & reeftop & other	0.0	21.4
	Soft benthos & mangrove	31.3	85.7
	Soft benthos & mangrove & reeftop & other	0.0	7.1
	Soft benthos & reeftop & other	12.5	0.0
	Mangrove	12.5	0.0
	Trochus	12.5	0.0
	Lobster	18.8	0.0
	Other	6.3	0.0

'Other' refers to giant clam fishery.
Finfish fisher interviews, males: n = 51; females: n = 20. Invertebrate fisher interviews, males: n = 16; females: n = 14.

Fishing patterns and fishing strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip are the basic factors used to estimate the fishing pressure imposed by people from Marau on their fishing grounds (Tables 3.2 and 3.3).

Our survey sample suggests that fishers from Marau have a good choice among sheltered coastal reef, lagoon and outer-reef fishing. As mentioned above, the same is true for invertebrate collection, as the community has access to intertidal, soft-benthos, reeftop, lagoon and mangrove areas (Figure 3.6). 'Other', representing 24% of the invertebrate fishery, is basically diving for giant clam species. Gender difference only shows in the fact that females do not particularly choose diving for invertebrates as an exclusive fishery. This category includes 'other' species (giant clams), trochus and lobsters and is a male fishers' domain. Although the female fishers of Marau do dive, they do so in combination with gleaning and other techniques (Figure 3.7).

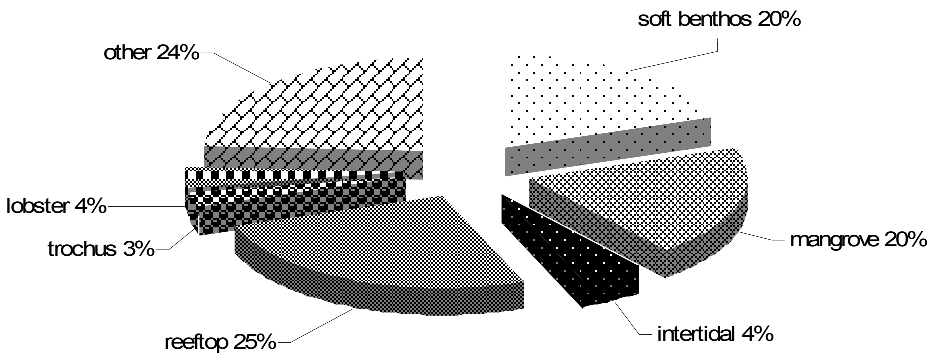

Figure 3.6: Proportion (%) of fishers targeting the seven primary invertebrate habitats found in Marau.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the giant clam and sea urchin fisheries.

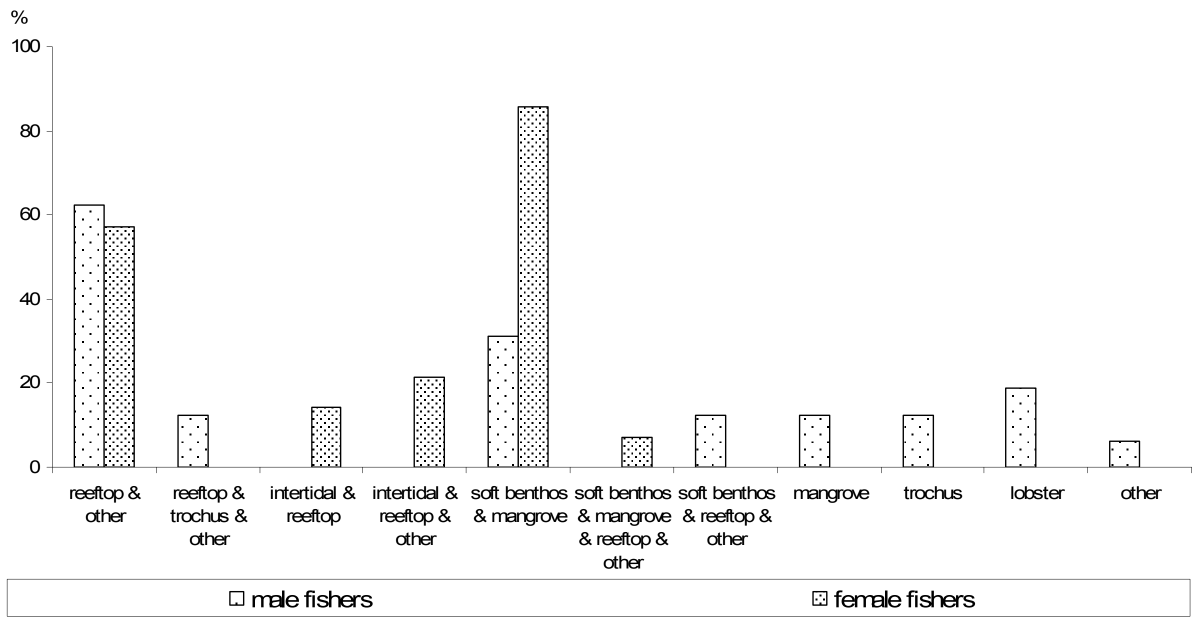

Figure 3.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Marau.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 16 for males, n = 14 for females.

Gear

Figure 3.8 shows that Marau fishers use a variety of different gear, that they may combine different fishing techniques if catching fish in a particular habitat, and that there is a predominance of low-cost fishing equipment used. Closer to shore, i.e. the combined fishing of the sheltered coastal reef and lagoon areas, handlines are used, followed by a combination of handlines with cast rods, spear diving, hand-held spearing, and drop stone. The combination of sheltered coastal and outer reef fishing uses castnets, also for catching bait, and handlining. Outer-reef fishing mainly uses handlines combined with cast rods, longlines, spear diving, hand-held spearing, trolling and drop stones. At the outer reef, there is also a group of fishers who specialise in spear diving. Gillnets are not commonly used, but may be used in combination with handlines and spear diving close to shore (Figure 3.8).

Concerning invertebrate collection, most activities involve very simple techniques, such as digging, collecting by hand or netting in tidal pools, seagrass beds and sand and mud flats, as well as in mangroves, using sticks, knives and other available tools.

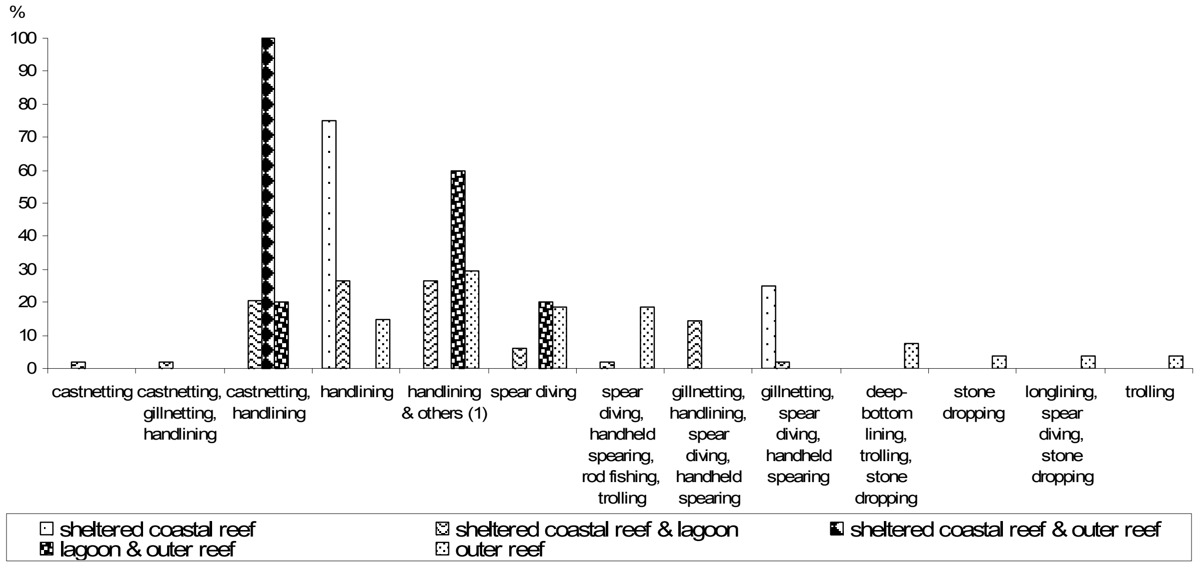

Figure 3.8: Fishing methods commonly used in different habitat types in Marau.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.
Handline & others (1) = rod casting, longlining, spear diving, handheld spearing, trolling, stone dropping.

Frequency and duration of fishing trips

The frequency of trips by male and female fishers to any of the finfish habitats is 1.5–2.5 times/week. As shown in Table 3.3, the fact than an average fishing trip targeting the outer reef, or a combination of lagoon and outer reef takes a long time (4–5 hours) may explain why female fishers fish closer to shore. Here, there is no marked difference between gender groups, both spend 3–4 hours on an average fishing trip.

Invertebrate harvesting is conducted less often than finfish fishing. Both male and female fishers harvest invertebrates ~1–1.5 times/week. Commercial fishing for trochus and lobsters is conducted less frequently, about once per fortnight. On average, an invertebrate collection trip takes ~3.5–5 hours, depending on whether diving is involved, in which further travel time is required to more distant fishing grounds. Trochus and lobster fishing take the longest time, which may explain why these activities are done less often (Table 3.3).

The frequency and duration of fishing trips may also be determined by the use of boats. Canoes are used for most finfish fishing trips. Boats may also be borrowed from other community members and, in the case of outer-reef fishing, motorised boats are used. Most of the finfish fishing is done during the day; tidal conditions are the most important factor for choosing the right time to fish at the outer reef. The preference for daytime fishing is very much influenced by the threat of crocodiles. This applies in particular for areas close to or inside mangrove swamps and habitats closer to shore. Finfish fishing is performed throughout the year and combined and interwoven with agricultural activities. The use of ice during fishing trips is not standard practice, but ice is often used on fishing trips targeting the combined lagoon and outer reef, or outer reef only, for sale at the Honiara market.

Almost all invertebrate collection is done using a canoe to reach the fishing ground or to support the diving and collection activities. Usually, invertebrates are collected all year round with no particular season. Almost all activities are exclusively performed during the day, and only half the lobster fishing trips are done at night. The presence of crocodiles is the major reason why fishing is done exclusively during the day.

Table 3.3: Average frequency and duration of fishing trips reported by male and female fishers in Marau

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	2.50 (±0.50)	2.00 (±0.00)	2.50 (±0.50)	2.50 (±0.50)
	Sheltered coastal reef & lagoon	2.33 (±0.14)	2.44 (±0.13)	3.52 (±0.12)	3.41 (±0.12)
	Sheltered coastal reef & outer reef	0	2.00 (n/a)	0	3.00 (n/a)
	Lagoon & outer reef	2.25 (±0.32)	1.50 (n/a)	4.25 (±0.75)	5.00 (n/a)
	Outer reef	1.85 (±0.14)	0	5.22 (±0.11)	0
Invertebrates	Reeftop & other	1.50 (±0.17)	1.59 (±0.28)	4.80 (±0.20)	4.13 (±0.48)
	Reeftop & trochus & other	1.50 (±0.50)	0	4.50 (±0.50)	0
	Intertidal & reeftop	0	1.25 (±0.75)	0	3.50 (±0.50)
	Intertidal & reeftop & other	0	1.17 (±0.44)	0	3.67 (±0.33)
	Soft benthos & mangrove	1.60 (±0.24)	1.33 (±0.14)	4.80 (±0.58)	4.42 (±0.23)
	Soft benthos & mangrove & reeftop & other	0	2.00 (n/a)	0	5.00 (n/a)
	Soft benthos & reeftop & other	1.50 (±0.50)	0	3.00 (±1.00)	0
	Mangrove	0.62 (±0.38)	0	3.50 (±0.50)	0
	Trochus	0.69 (±0.00)	0	5.50 (±0.50)	0
	Lobster	0.32 (±0.09)	0	5.67 (±0.33)	0
	Other	1.00 (n/a)	0	3.00 (n/a)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam fishery.
Finfish fisher interviews, males: n = 51; females: n = 20. Invertebrate fisher interviews, males: n = 16; females: n = 14.

3.2.3 Catch composition and volume – finfish: Marau

Over half (~54%) of the reported catches from the sheltered coastal reef are determined by *Lutjanus gibbus*, *Plectorhinchus celebicus*, *Amphiprion clarkia* and *Selar crumenophthalmus*. The presence and importance of these species were also reported for catches from the sheltered coastal reef and lagoon, although the reported biodiversity of these catches is much higher. Also, *Epinephelus* spp., Scaridae, Acanthuridae and Carangidae contribute substantially. With distance from shore, reported catch composition changes. The catch reported for the combined fishing of the lagoon and outer reef is dominated by three species that determine ~30% of the total catch, i.e. *Naso* spp., *Lutjanus sebae* and *Aphareus furca*. Other important species belong to the families of Scombridae, Haemulidae, Balistidae, Scaridae, and Acanthuridae. Outer-reef catches were reported to have the highest biodiversity. Here, about seven species represent ~41% of the total reported catch: *Epinephelus* spp., *Scarus rubroviolaceus*, *Sphyraena* spp., *Naso* spp, *Scomberomorus* spp., *Lutjanus sebae* and *Lutjanus gibbus*. There are about another 50 species that make up the remaining 60% of catches reported from the outer reef. Detailed information on catch compositions by species, species groups and habitats are reported in Appendix 2.2.1.

Figure 3.9 highlights findings from the socioeconomic survey reported earlier, that finfish fishing not only serves subsistence needs but is also very important for generating income. The total annual catch is estimated to amount to ~435 t, of which ~46% is used for subsistence needs, while ~54 % is sold mostly to the Honiara market. While participation in finfish fisheries did not vary much between gender groups, male fishers account for 82% of the total catch; females catch ~18% only. As reported earlier, the preference of female fishers to stay closer to shore also shows in the accumulated impact of both gender groups, i.e. ~58% of the total impact is imposed on the sheltered coastal reef and lagoon. The remaining ~40% is partly due to the lagoon catch (combined lagoon and outer reef catches account for ~6% of the total reported catch), but a substantial amount is from the outer reef (35%).

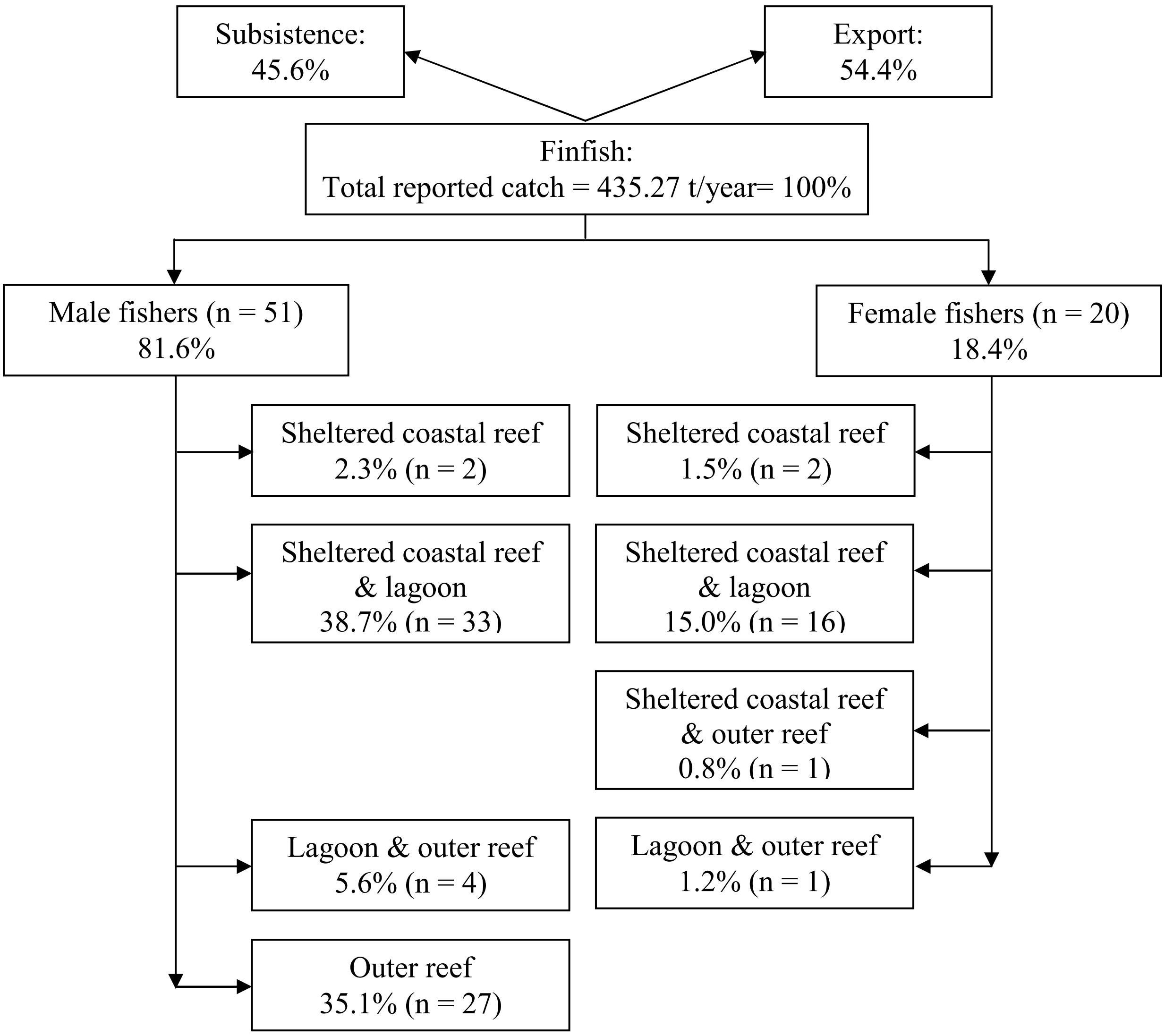

Figure 3.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Marau.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The distribution of annual catch weight between the more easily accessible sheltered coastal reef and lagoon and the more distant outer reef is a consequence of the number of fishers rather than differences in the annual catch rates. As shown in Figure 3.10, the average annual catch per fisher does not vary substantially between areas closer to shore and the outer reef. While the average annual catch per fisher targeting the sheltered coastal reef alone or in combination with the lagoon amounts to ~400 kg, the combined fishing of lagoon and outer reef or outer reef fishing alone renders about 100 kg more, i.e. ~480–500 kg/fisher/year. The difference in the average annual catch between male fishers and female fishers is also not large if comparing figures for the same habitats fished.

Comparing productivity rates between genders and among habitats (Figure 3.11), there are no obvious differences between male and female fishers. However, overall, CPUEs are low and hardly exceed 1.5 kg/hour of fishing trip. This result may suggest two things: firstly, the non-motorised canoes and low-cost fishing gear used are less efficient; secondly, the resource status may be low.

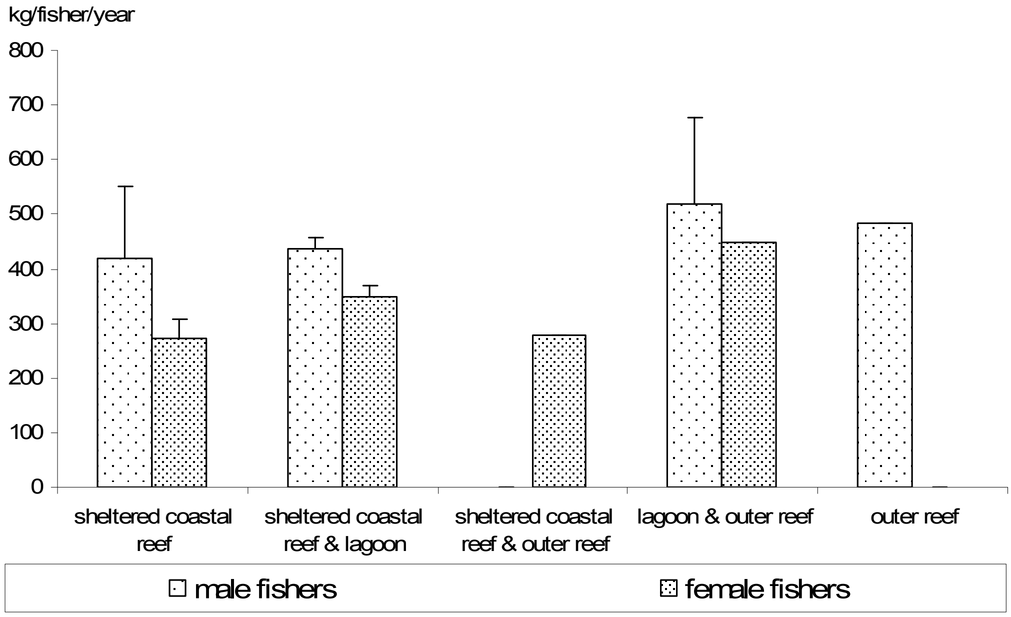

Figure 3.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Marau (based on reported catch only).

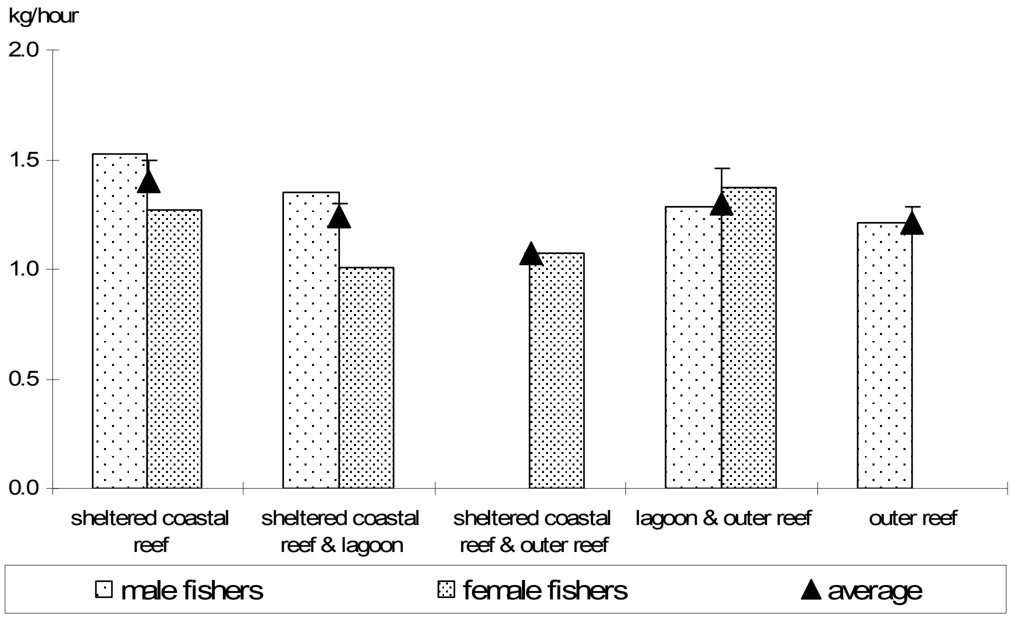

Figure 3.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Marau.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The almost equal importance of subsistence and commercial fishing for the community of Marau clearly shows in Figure 3.12. As observed earlier, male fishers targeting the outer reef (first fishing in the lagoon to catch bait) mainly fish for income. Fishing in the sheltered coastal reef and lagoon, which is performed by most fishers in Marau, is predominantly done to provide food for the family and the community and, to a much lesser extent, to provide income. Because female fishers only target the sheltered coastal reef and lagoon, it can also be concluded that their participation in commercial finfish fishing is very low.

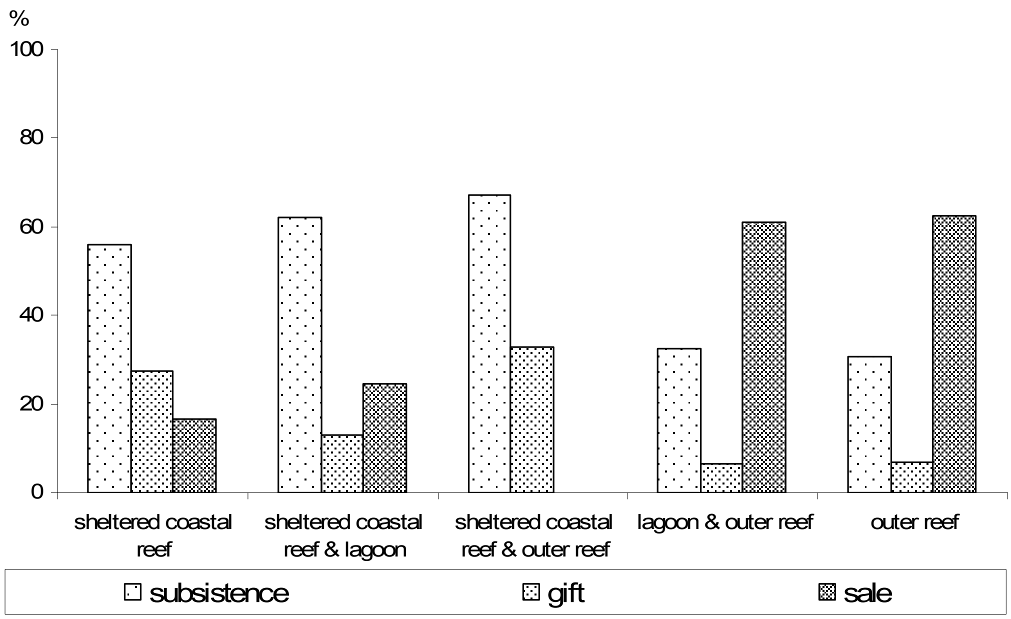

Figure 3.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Marau.
Proportions are expressed in % of the total number of trips per habitat.

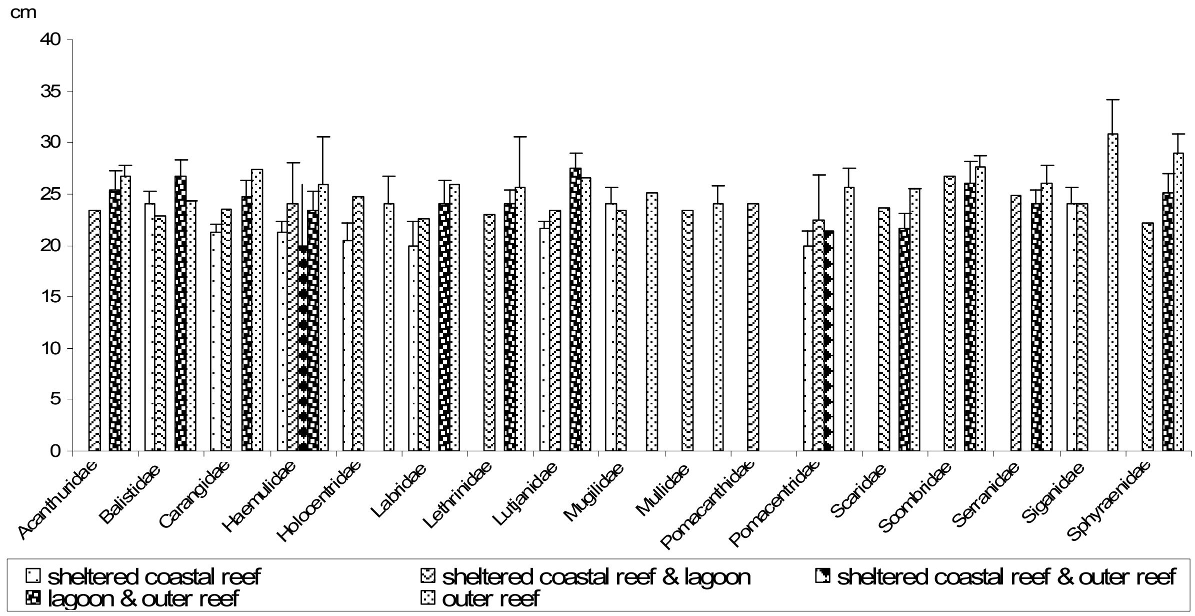

Figure 3.13: Average sizes (cm fork length) of fish caught by family and habitat in Marau.
Bars represent standard error (+SE).

Comparison of the overall finfish fishing productivity among habitats is not conclusive concerning resource status (Figure 3.11). If comparing the reported average fish size across all habitats (Figure 3.13), the expected trend, i.e. an increase in average fish size with distance from shore, becomes apparent for various families, i.e. Acanthuridae, Carangidae, Holocentridae, Labridae, Lethrinidae, Lutjanidae and Sphyraenidae. Others, such as Scaridae and Serranidae, do not show significant differences in fish size among habitats. Overall, average reported fish length is ~25 cm.

The parameters selected to assess current fishing pressure on Marau's reef and lagoon resources are shown in Table 3.4. Most fishers target either the combined sheltered coastal reef and lagoon or the outer reef. In order to assess possible fishing pressure, the lagoon surface was considered only for the combined fishing category. Accordingly, fisher densities are low-to-moderate for the individually assessed habitats, except for the outer reef, which has a high fisher density (55 fishers/km²). If taking into account the total available reef area and the total available fishing ground, fishing pressure indicators are moderate-to-high. These include fisher density, population density and also the subsistence catch per km². The latter is particularly high if taking into account the fact that subsistence catches account for less than half of the total annual catch, i.e. actual fishing pressure is more than double for both the total reef and the total fishing ground.

Table 3.4: Parameters used in assessing fishing pressure on finfish resources in Marau

Parameters	Habitat						
	Sheltered coastal reef	Sheltered coastal reef & lagoon [(4)]	Sheltered coastal reef & outer reef	Lagoon & outer reef	Outer reef	Total reef	Total fishing ground
Fishing ground area (km^2)	3.97	23.52	n/a	n/a	4.80	20.75	32.30
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	15	27	n/a	n/a	55	51	33
Population density (people/km^2) [(2)]						108.2	69.5
Average annual finfish catch (kg/fisher/year) [(3)]	345.52 (±70.27)	407.21 (±17.47)	279.16 (n/a)	505.60 (±121.34)	482.73 (±33.37)		
Total fishing pressure of subsistence catches (t/km^2)						9.3	6.0
Total number of fishers	60	646	20	59	265	1050	1050

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; [(1)] total number of fishers is extrapolated from household surveys; [(2)] total population = 2244; total number of fishers = 1050; total subsistence demand = 194.0 t/year; [(3)] catch figures are based on recorded data from survey respondents only; [(4)] lagoon surface considered only.

3.2.4 Catch composition and volume – invertebrates: Marau

Compiling the catches reported from invertebrate fishers by wet weight shows that only three species account for the major annual impact expressed in wet weight (Figure 3.14). The combined catches of *Tridacna maxima*, *Scylla serrata* and *Trochus niloticus* alone account for 16.3 t/year or 61% of the total annual reported catch (wet weight). Other important target species are *Sipunculus* sp., *Holothuria* sp., and *Strombus* spp. By comparison, lobsters, *Donax cuneatus*, *Tripneustes gratilla*, *Lambis lambis*, octopus and *Pinctada margaritifera* are of insignificant impact. There are also another five species or species groups that are collected but which do not play any important role.

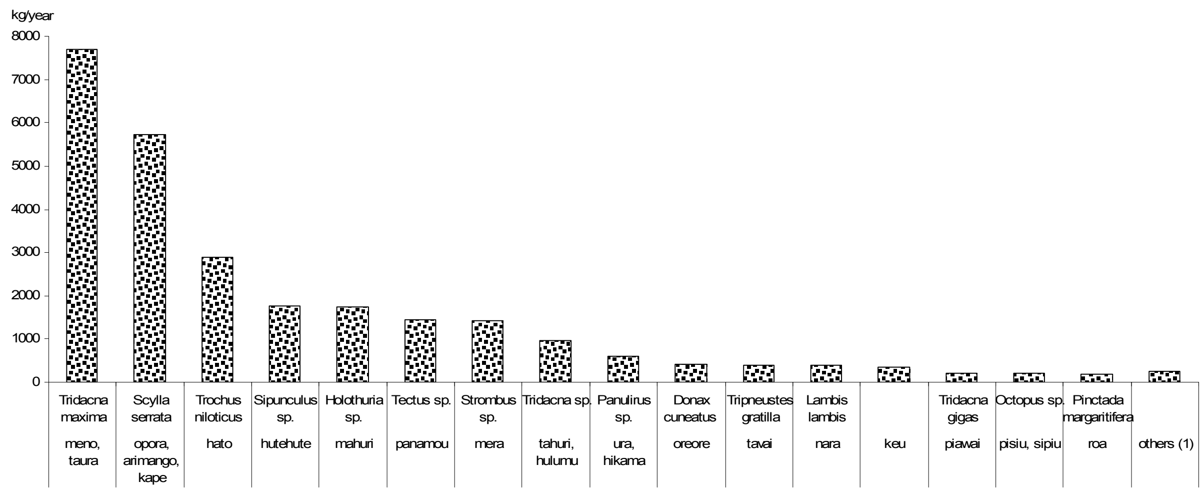

Figure 3.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Marau.
'Others (1)' include: *Telescopium telescopium* (*u*), *Nerita* spp. (*meta*), *Modiolus auriculatus* (*deo*), *Terebralia palustris* (*ropi*), *Nerita polita* (*sise*) (all <200 kg/year).

The fact that most impact is on a few species only also shows in the number of vernacular names that have been recorded from respondents (Figure 3.15). Reeftop gleaning and diving for mostly reef-associated species are described by the highest number of vernacular names (12), while mangrove fishing has two names, and trochus and lobster fisheries one vernacular name only. Figure 3.15 also highlights that the Marau fishers like to combine a number of different habitats in one gleaning trip.

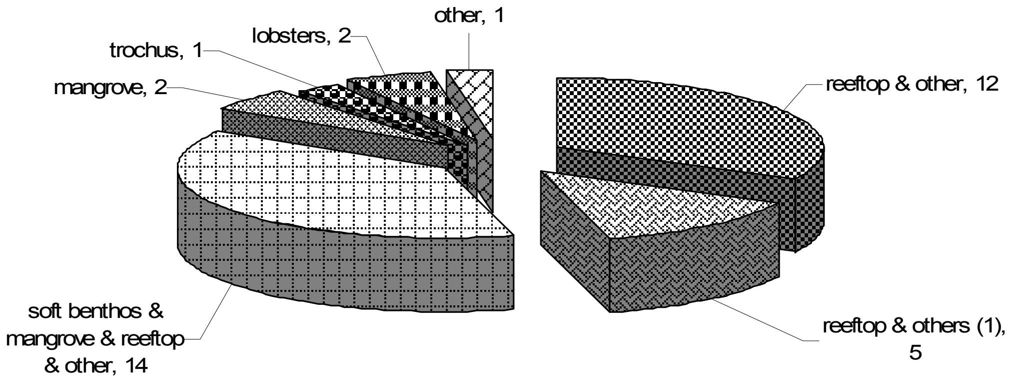

Figure 3.15: Number of vernacular names recorded for each invertebrate fishery in Marau.
'Other' refers to the giant clam fishery; 'others (1)' refers to the trochus, other, intertidal and soft-benthos fisheries.

The average annual catch per fisher by gender and fishery (Figure 3.16) reveals substantial differences among fisheries. Most fisheries produce very low catches, i.e. ~55–400 kg/fisher/year for most. Only combined fisheries, i.e. soft benthos and reeftop and other, soft benthos and mangrove; reeftop, trochus and other; intertidal, reeftop and other gleaning, reach catch rates of ~800–1000 kg/fisher/year. Because the participation of male and female fishers in the various fisheries and combinations of fisheries differs substantially, average annual catch rates cannot be compared by gender and fishery.

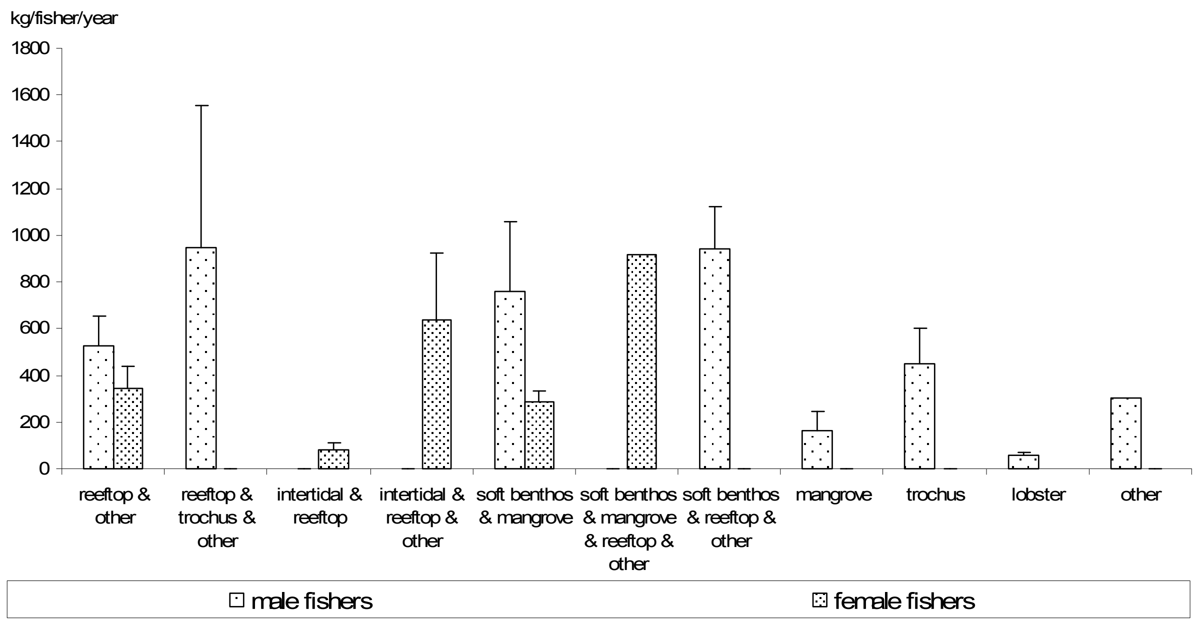

Figure 3.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Marau.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 16 for males, n = 14 for females); 'other' refers to the giant clam fishery.

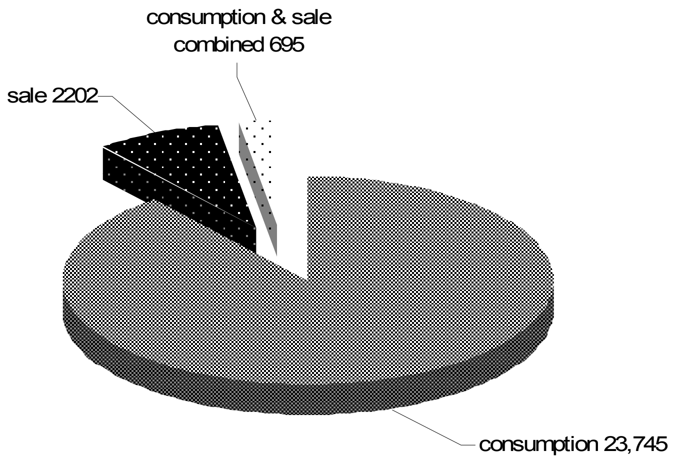

Figure 3.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Marau.

The above observation that invertebrate collection mainly serves subsistence needs but also, to some extent, income generation in Marau, is confirmed by results shown in Figure 3.17. The proportion of the invertebrate catch that is sold on the local markets may not exceed 9.6% of the total annual reported catch or 2550 kg/year if assuming that half of the share that may be consumed or sold is indeed sold. There is no reported species or catch that is exclusively collected for sale. This also applies to trochus catches, as the meat is locally consumed, while only the shells are sold.

As mentioned earlier, male fishers in Marau are engaged in invertebrate fisheries as much as females. This shows in the proportion of total annual catch that male and female fishers take (62% and 38% respectively) (Figure 3.18). Most of Marau's male invertebrate fishers target the reeftop by gleaning and collecting giant clams, perhaps also trochus, by diving ('other'), and these take the highest proportion of total annual catches (wet weight) (~31%). Female fishers add another ~12% of total annual catch from the reeftop resources. As shown by average annual catches and numbers of fishers, soft benthos and mangroves resources account for the second-highest annual impact by wet weight (~35% of total annual catches). The impact on lobsters, trochus and giant clams if targeted exclusively is negligible by comparison (3.8%, 0.7% and 1.3% respectively of total annual reported catch by wet weight).

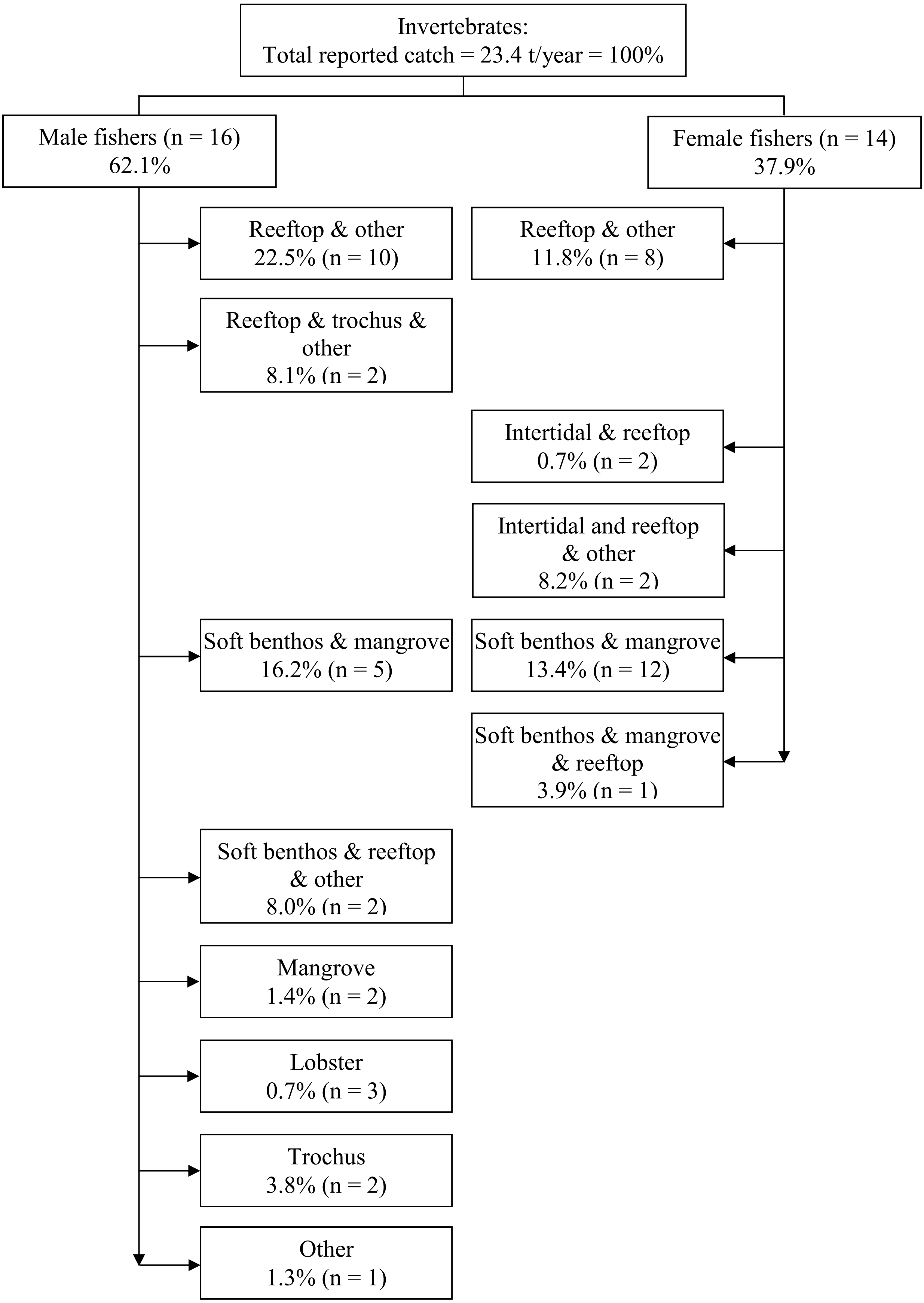

Figure 3.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Marau.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; ‘other’ refers to the giant clam fishery.

Table 3.5: Parameters used in assessing fishing pressure on invertebrate resources in Marau

Parameters	Fishery / Habitat				
	Reeftop & other (5)	Reeftop & trochus & other (5)	Intertidal & reeftop	Intertidal & reeftop & other	Soft benthos & mangrove
Fishing ground area (km^2)	11.59	7.95	n/a	n/a	n/a
Number of fishers (per fishery) (1)	564	59	67	100	549
Density of fishers (number of fishers/km^2 fishing ground)	48.6	7.5	n/a	n/a	n/a
Average annual invertebrate catch (kg/fisher/year) (2)	446.22 (±83.92)	945.66 (±606.91)	83.60 (±24.97)	637.68 (±285.22)	424.45 (±104.16)

Parameters	Fishery / Habitat					
	Soft benthos & mangrove & reeftop & other	Soft benthos & reeftop & other	Mangrove	Trochus	Lobster (4)	Other (5)
Fishing ground area (km^2)	n/a	n/a	n/a	7.95	16.1	7.95
Number of fishers (per fishery) (1)	33	59	59	59	89	30
Density of fishers (number of fishers/km^2 fishing ground)	n/a	n/a	n/a	7.5	5.5	3.7
Average annual invertebrate catch (kg/fisher/year) (2)	919.60 (n/a)	941.10 (±181.10)	161.36 (±81.84)	449.75 (±149.92)	55.60 (±15.63)	304.00 (n/a)

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) inside lagoon shallow reef area considered only; (4) outer-reef linear measurement; (5) outer-reef area.

Taking into account the figures available on the fishing habitat surfaces, reeftop fisheries have, as expected, high fisher density. There is a large number of fishers, both males and females, targeting reef resources alone, and in combination with species in other habitats. Surface areas for soft benthos and mangroves are difficult to determine. Thus, it can only be speculated that most of the fishing pressure is in fact imposed on the community's accessible reef resources, and also substantially targets mangrove and soft-benthos species. Considering that giant clams are among the most targeted species, negative impacts may already show, as these bivalves are subject to long recuperation periods. The extensive outer-reef length that is considered to support the lobster dive fishery, coupled with the small number of fishers who harvest lobsters, results in a low fishing pressure for lobster fishing alone. The fisher density for the potential trochus habitat is moderate, the average annual catches are low and the total number of fishers engaged in this commercial fishery is also low. All suggest that the trochus resource status is low (Table 3.5). Before a final assessment is made, however, these results need to be compared with the results from the resource surveys.

3.2.5 Management issues: Marau

There are three levels of fisheries management activities that apply to the Marau community. Firstly, regulations such as the temporary ban on bêche-de-mer fisheries, collection sizes for trochus, periodic closure of turtle harvesting during nesting periods, and restrictions on the use of detrimental fishing activities, including fish poisoning and dynamite, are imposed by national legislation under the authority of the Fisheries Department. Secondly, projects are undertaken by NGOs and other management and research institutions, notably TNC, FSPI, WorldFish, WWF and IUCN. Thirdly, there is a strong component of community-management activities based on traditional institutions.

Historic traditional measures included placing fishing bans on certain reef areas and for a certain period of time when a prominent person of the community died. Also, when deemed necessary, chiefs could impose seasonal or temporary bans on fishing grounds, certain areas or selected species. This was often done in preparation for community fishing for traditional and social functions. There were, and still are, particular bans related to females' engagement in fisheries. Females are banned from participating in certain fishing activities, from fishing in certain areas, and from being on canoes with other people when considered unclean (during menstruation). One of the Marau communities, i.e. Suu, forbids females to walk in certain parts of the village, the beachfront and areas near ancestral grounds. Another island community of Marau had strict rules against females approaching the island.

Community-based fisheries management has been supported and improved by partnerships with external partners, including WWF, FSPI, TNC, WorldFish, IUCN and USP. In the case of Marau, it is mainly FSPI that had an ongoing partnership with the community in regard to sustainable exploitation of target species for subsistence and for commercial purposes. The Fisheries Department has contributed to this partnership by conducting invertebrate resource surveys. However, there is a need to bring together the governmental authority, FSPI, and the community members to improve the efficiency of and compliance with the fisheries management measures. In addition to certain areas being naturally protected (in particular mangroves and muddy areas, which are avoided because of crocodiles), there are a number of *tabu* areas. Social conflicts arise when these areas are close to the village, and people (including children) are found fishing in these areas. These conflict situations are highlighted by a reported case where the canoe of a boy fishing in an MPA for food and another canoe belonging to his family were completed destroyed, and the boy was beaten by the village MPA monitor.

Although social and traditional institutions are still strong in the Marau area, there are also opinions and reactions that these are, at least partly, outdated. Also, compliance with known rules, be they governmental or made by the community, is not given at any point. For instance, the temporary ban on bêche-de-mer harvesting is not fully respected, as one of the major invertebrate species collected was reported to be *mahuri* (*Holothuria* spp.). However, no information was provided on what people did with this catch.

3.2.6 Discussion and conclusions: socioeconomics in Marau

The Marau community is isolated and best described as a rural coastal community that is scattered over small islands and part of the mainland in the Guadalcanal district. Its isolation is not necessarily because of the long distance to the capital city of Honiara but due to the difficult and expensive transportation linkages. This isolation, the lack of transport and marketing infrastructure, lack of access to electricity, ice or other preservation facilities, as well as the loss of a market centre in Marau, have resulted in people living a self-sustained, low-income lifestyle, with few opportunities for change, salaries or purchasing power for imported food items. The lifestyle here is determined by traditional institutions and leadership and the influence of the resettled Malaita people who arrived as a result of the ethnical conflicts in 2000. People have access to agricultural land on the mainland and to a variety of marine resources. Commercialisation of fisheries produce is limited to the fortnightly visits by middlemen and agents, the selling of certain species on demand (e.g. lobsters) to Honiara clients, the selling of trochus shells on a monthly basis to agents, the sale of aquarium trade species, and limited local market demand on a fortnightly basis. Because the middlemen also market fish from many other areas as well as Marau, oversupply on the Honiara market keeps prices low. The former bêche-de-mer fishery, an important income source for both males and females in many households, is currently banned temporarily by government interventions. Fisheries are the most important income source, followed by agricultural produce and some earnings from wood carvings, handicrafts and small business (betel nut and lime selling).

Although traditional *tabu* and management rules apply, complemented by governmental regulations and cooperation with NGOs and other institutions aiming to improve fisheries management and setting aside marine protected areas (MPAs), fishing pressure is high and presumably exceeding sustainable productivity of the community's coral reef and lagoon systems.

In summary, survey results suggest:

- Marau's population has an important dependence on their marine resources for income and home consumption. Fresh fish consumption (101 kg/person/year) is high and represents the most important food and protein source.

- Tradition does not demand particular gender roles, although females are banned from certain fishing activities and areas. Females are the only exclusive invertebrate fishers, while males are the only exclusive finfish fishers. However, most male and female fishers fish for both finfish and invertebrates.

- Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers and is intended for commercial purposes.

- Overall, CPUEs are low, oscillating around 1.5 kg fish/hour of fishing trip, due to inefficient fishing techniques and low-cost fishing gear, and/or low resource status.

- A wide range of traditional and mostly low-cost fishing techniques is used, often in combination. The average reported fish size is about 25 cm. Most families show the expected increase in average fish size with distance from shore.

- Results from the invertebrate fisher survey show that catches of giant clams, in particular *Tridacna maxima*, the crab *Scylla serrata*, trochus, *Sipunduculus* spp., *Holothuria* spp., *Tectus* spp. and *Strombus* spp. account for most of the annual harvest (wet weight). These species are used for commercial and subsistence needs.

- In contrast to finfish fishing, significant differences were found in the average annual invertebrate catches by fishery. Annual average catches reported for the combined gleaning of reeftops and diving for giant clams, and the combination of soft benthos with mangroves, reeftops and other show by far the highest average annual catches, while all other fisheries produce rather small catches.

- Indicators of fishing pressure calculated for finfish fisheries suggest that, due to the available reef and overall fishing ground areas, fisher and population densities and subsistence catch per available surface unit area are high. Generally speaking, the current exploitation level of invertebrates for subsistence and, to a lesser extent, for commercial use is not alarmingly high; however, fisher density is high for reeftop gleaning and diving for giant clams. The fact that the reported average annual catches of trochus are low, and that not many fishers are engaged in this commercial fishery suggests that the resource status is low. This may also apply to giant clams, one of the most sought-after species groups.

3.3 Finfish resource surveys: Marau

Finfish resources and associated habitats were assessed between 24 and 30 June 2006, from a total of 24 transects (6 sheltered coastal, 6 intermediate, 6 back- and 6 outer-reef transects; see Figure 3.19 and Appendix 3.2.1 for transect locations and coordinates respectively).

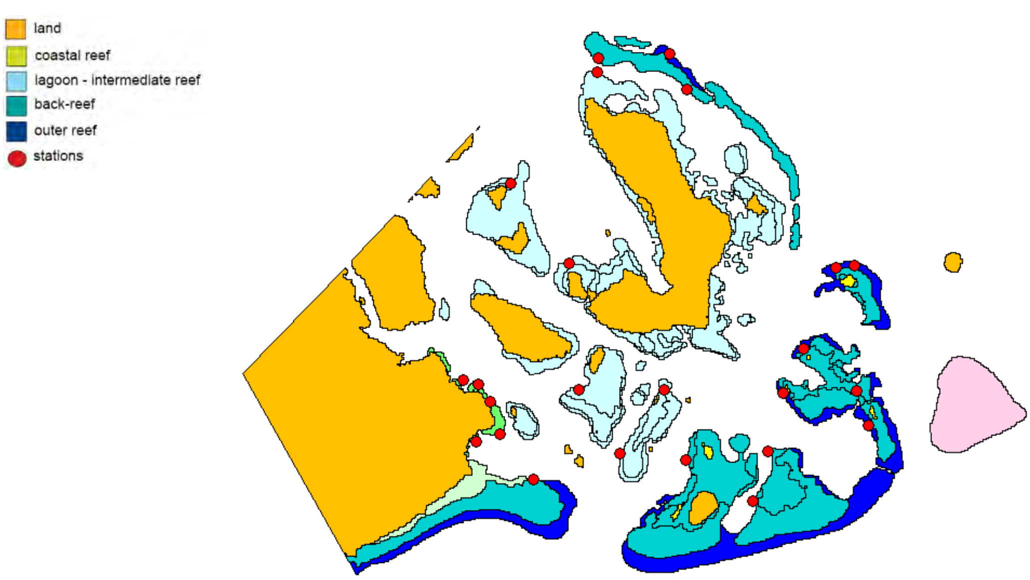

Figure 3.19: Habitat types and transect locations for finfish assessment in Marau.

3.3.1 Finfish assessment results: Marau

A total of 212 families, 60 genera, 184 species and 10,290 fish were recorded in the 24 transects (See Appendix 3.2.2 for list of species.). Only data on the 15 most dominant families (See Methods.) are presented below, representing 47 genera, 162 species and 8871 individuals.

Finfish resources differed greatly among the reef environments found in Marau (Table 3.6). The intermediate reef contained the lowest density of fish (0.62 fish/m^2), biomass (134 g/m^2), size (19 cm FL) and size ratio (59%) but the highest number of species (54 species/transect) among all other reef habitats. At the other extreme, the back-reef displayed the highest density (0.73 fish/m^2), biomass (266 g/m^2), size (23 cm FL) and size ratio (64%) but lowest biodiversity (35 species/transect) at the site. The coastal reefs displayed higher values of size, size ratio and biomass but lower density than the outer reef.

Table 3.6: Primary finfish habitat and resource parameters recorded in Marau (average values ±SE)

Parameters	Habitat				
	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	0.4	3.4	12.1	4.8	20.7
Depth (m)	6 (1–14) (3)	6 (1–13) (3)	7 (1–16) (3)	7 (1–13) (3)	7 (1–16) (3)
Soft bottom (% cover)	21 ±7	10 ±3	26 ±6	8 ±3	19
Rubble & boulders (% cover)	6 ±3	8 ±2	10 ±7	3 ±1	8
Hard bottom (% cover)	46 ±5	54 ±4	46 ±10	64 ±4	52
Live coral (% cover)	25 ±7	28 ±6	17 ±5	24 ±2	20
Soft coral (% cover)	1 ±1	1 ±0	0 ±0	1 ±0	0
Biodiversity (species/transect)	46 ±5	55 ±4	39 ±8	51 ±7	47 ± 3
Density (fish/m^2)	0.6 ±0.2	0.6 ±0.1	0.7 ±0.2	0.7 ±0.1	0.7
Size (cm FL) (4)	22 ±1	19 ±1	23 ±1	20 ±1	21
Size ratio (%)	64 ±2	59 ±2	64 ±3	61 ±2	63
Biomass (g/m^2)	239.0 ±15.2.0	133.6 ±23.9	266.3 ±131.5	182.1 ±32.2	224.3

(1) Unweighted average; (2) weighted average that takes into account relative proportion of habitat in the study area; (3) depth range; (4) FL = fork length.

Sheltered coastal reef environment: Marau

The sheltered coastal reef environment of Marau was dominated by five families: herbivores Acanthuridae and Scaridae, and carnivores Lutjanidae, Lethrinidae and Mullidae. Lutjanidae displayed the highest biomass (Figure 3.20). These families were represented by 51 species; particularly high abundance and biomass were recorded for: *Ctenochaetus striatus*, *Monotaxis grandoculis*, *Mulloidichthys vanicolensis*, *Lutjanus monostigma*, *Acanthurus xanthopterus*, *Lutjanus gibbus*, *L. fulvus*, *Scarus psittacus*, *L. rivulatus* (Table 3.7). This reef environment was dominated by hard bottom (46%) and displayed a high percentage of live coral (25%) and soft coral (21%). Such diverse habitat was reflected in the diversity of fish community composition (Table 3.6 and Figure 3.20).

Table 3.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Marau

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.08 ±0.04	7.5 ±4.2
	Acanthurus xanthopterus	Yellowfin surgeonfish	0.02 ±0.02	26.7 ±26.7
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.04 ±0.02	14.5 ±11.7
Lutjanidae	*Lutjanus monostigma*	Onespot snapper	0.03 ±0.03	26.7 ±26.7
	Lutjanus gibbus	Humpback snapper	0.02 ±0.02	16.0 ±15.7
	Lutjanus fulvus	Flametail snapper	0.02 ±0.01	6.8 ±5.1
	Lutjanus rivulatus	Blubberlip snapper	0.01 ±0.01	18.8 ±18.8
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	0.04 ±0.03	34.5 ±28.3
Scaridae	*Scarus psittacus*	Common parrotfish	0.02 ±0.01	4.6 ±0.9

The biodiversity and density of fish in the coastal reefs of Marau were the second-lowest among the four habitats at this site but the highest among the three coastal reef habitats in the country.

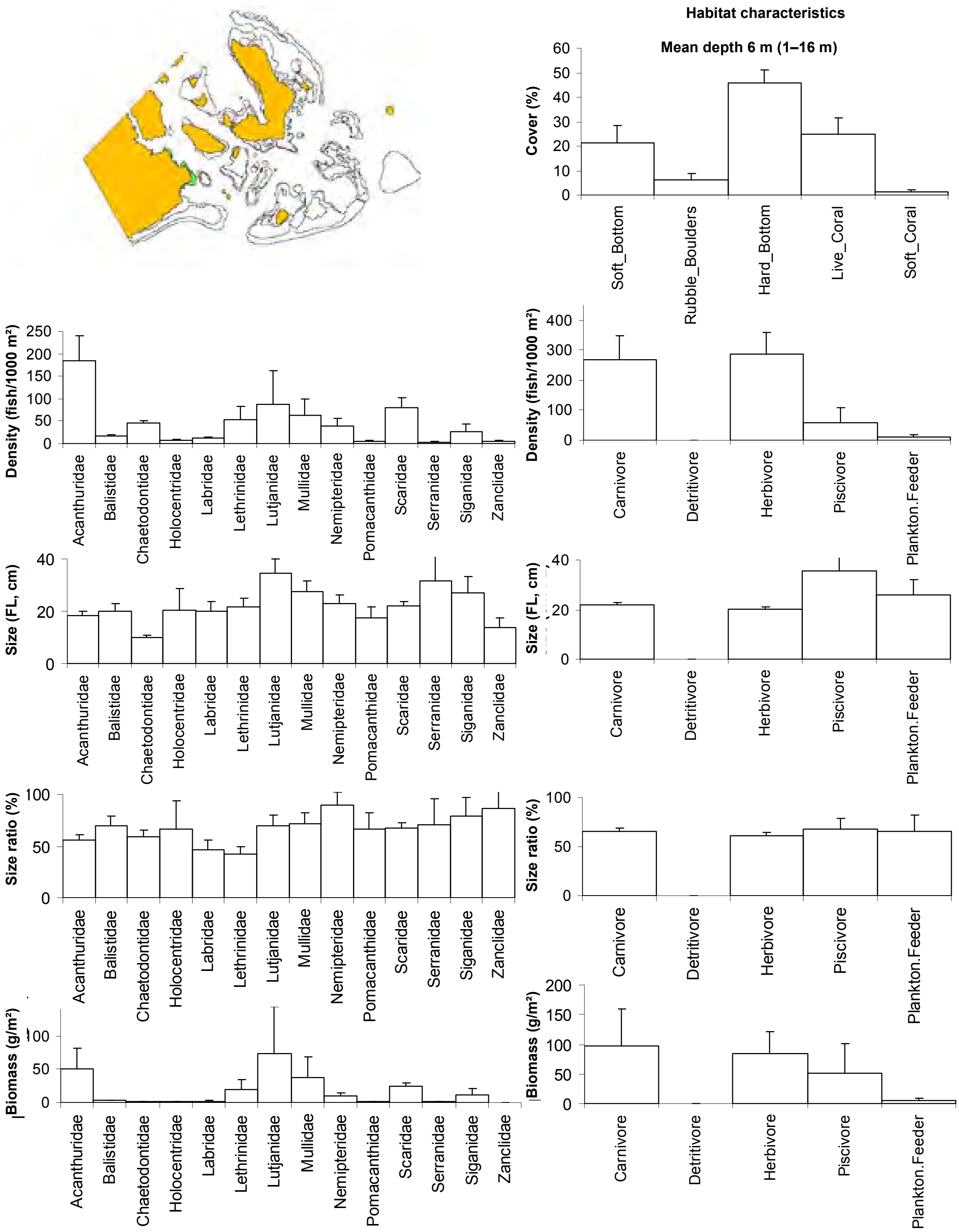

Figure 3.20: Profile of finfish resources in the sheltered coastal reef environment of Marau.
Bars represent standard error (+SE); FL = fork length.

Size, size ratio and biomass were second-highest after the back-reefs, and still the highest among all three coastal reefs studied. Average size ratios were low only for Labridae and Lethrinidae, while all other families displayed size ratios higher than 65%. Trophic structure was equally composed of herbivorous and carnivorous fish in term of density, while carnivores were more important in terms of biomass. Lutjanidae was the most important carnivore family, followed by Mullidae and Lethrinidae.

Intermediate-reef environment: Marau

The intermediate-reef environment of Marau was dominated by five families: herbivorous Acanthuridae and Scaridae, and carnivorous Lethrinidae, Lutjanidae and Mullidae (Figure 3.21). These five families were represented by 49 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Acanthurus pyroferus*, *Mulloidichthys flavolineatus*, *Chlorurus sordidus*, *Monotaxis grandoculis*, *Gnathodentex aureolineatus*, *Scarus psittacus*, *Naso lituratus* and *Macolor macularis* (Table 3.8). This reef environment presented a moderately diverse habitat with dominance of hard bottom (54%), good cover of live coral (28%) and little soft bottom (10%) (Table 3.6 and Figure 3.21). The dominance of hard bottom usually favours the presence of herbivores, as observed here.

Table 3.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Marau

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Orangespine unicornfish	0.08 ±0.02	6.0 ±1.4
	Acanthurus pyroferus	Chocolate surgeonfish	0.03 ±0.01	3.4 ±1.3
	Naso lituratus	Common parrotfish	0.01 ±0.01	4.9 ±3.5
Lethrinidae	*Monotaxis grandoculis*	Yellowstripe goatfish	0.02 ±0.01	8.7 ±5.0
	Gnathodentex aureolineatus	Black parrotfish	0.02 ±0.01	5.0 ±3.4
Lutjanidae	*Macolor macularis*	Striated surgeonfish	0.01 ±0.01	7.1 ±6.8
Mullidae	*Mulloidichthys flavolineatus*	Black snapper	0.03 ±0.03	7.2 ±7.2
Scaridae	*Chlorurus sordidus*	Bigeye bream	0.03 ±0.01	9.6 ±5.2
	Scarus psittacus	Orangestriped triggerfish	0.02 ±0.01	3.9 ±2.4

The density, size ratio and biomass of fish in the intermediate reefs of Marau were the highest recorded at the site and much higher than values of the intermediate reefs of Chubikopi and Rarumana. Biodiversity was the highest among the reef habitats of Marau, and still much higher than at Chubikopi and Rarumana intermediate reefs (Table 3.6). At a family level, size ratios were low only for Balistidae, Kyphosidae, Labridae and Mullidae. All other families displayed size ratios higher than 55%. Herbivorous fish only slightly dominated the trophic structure of the fish community, both in terms of density and biomass. Carnivorous fish were well represented by Lethrinidae, Lutjanidae and Mullidae, while Serranidae and Labridae were very rare.

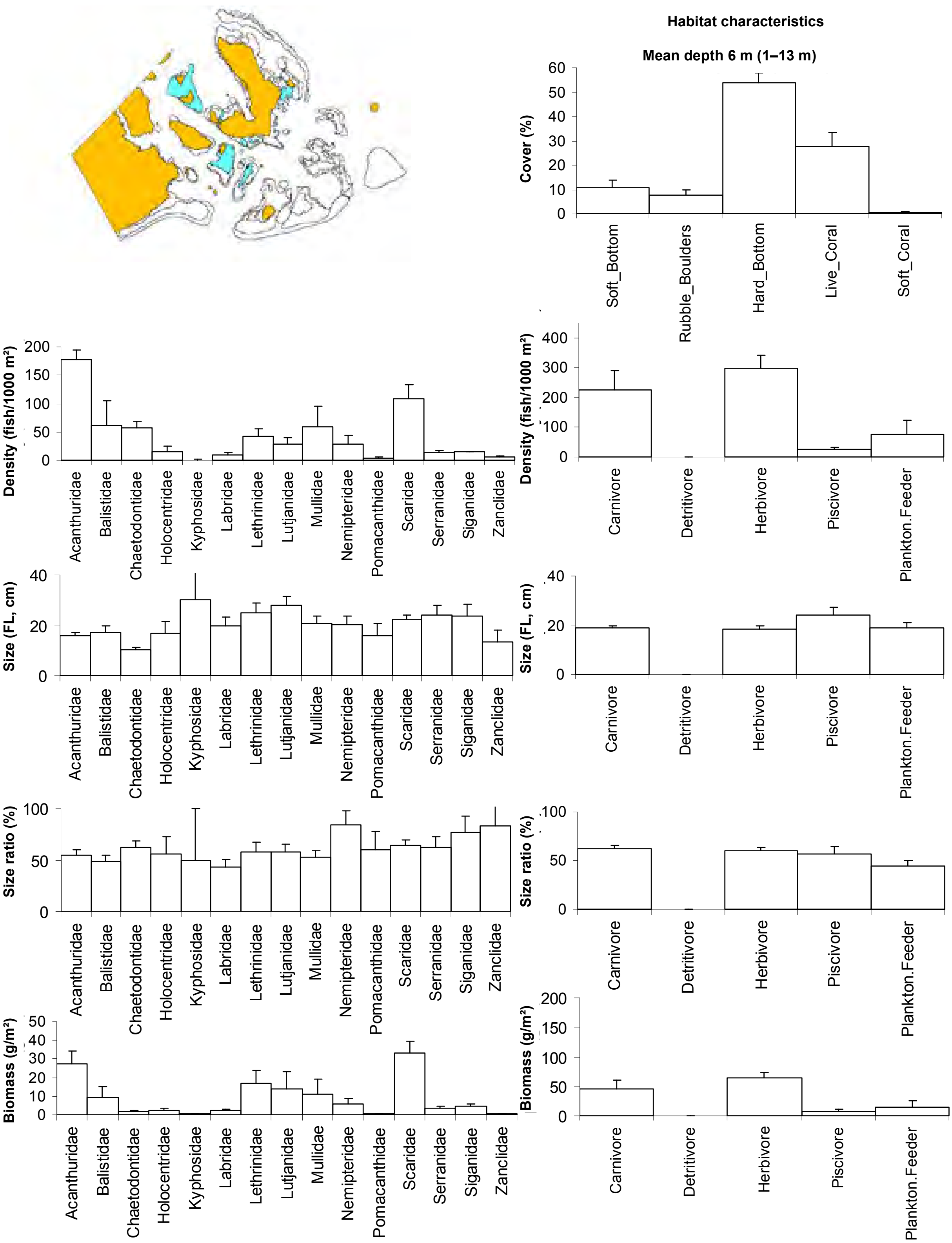

Figure 3.21: Profile of finfish resources in the intermediate-reef environment of Marau.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Marau

The back-reef environment of Marau was dominated by four families: herbivorous Acanthuridae and carnivorous Lutjanidae, Mullidae and Lethrinidae (Figure 3.22). These four families were represented by 38 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Lutjanus gibbus*, *Acanthurus olivaceus*, *A. lineatus*, *Mulloidichthys flavolineatus*, *Acanthurus mata*, *Monotaxis grandoculis*, *Gnathodentex aureolineatus*, *Mulloidichthys vanicolensis* and *A. blochii* (Table 3.9). This reef environment presented a diverse habitat with dominance of hard bottom (47%), high cover of soft bottom (26%) and relatively poor live coral (17%, Table 3.6 and Figure 3.22).

Table 3.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Marau

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.09 ±0.06	7.6 ±4.8
	Acanthurus olivaceus	Orangeband surgeonfish	0.03 ±0.01	6.6 ±3.1
	Acanthurus lineatus	Lined surgeonfish	0.03 ±0.02	8.2 ±7.4
	Acanthurus mata	Elongate surgeonfish	0.02 ±0.02	30.1 ±26.2
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.01	15.4 ±10.5
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.02 ±0.01	17.5 ±10.6
	Gnathodentex aureolineatus	Goldlined seabream	0.02 ±0.02	7.9 ±7.9
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.05 ±0.04	35.6 ±27.6
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.03 ±0.03	7.9 ±7.9
	Mulloidichthys vanicolensis	Yellowfin goatfish	0.02 ±0.02	11.3 ±11.3

The density, size, size ratio and biomass of finfish in Marau back-reefs were the highest at the site, while biodiversity was the lowest. All these parameters were, however, the highest among the three back-reefs analysed (Rarumana and Chubikopi being the other two). The trophic structure in Marau back-reefs was only slightly dominated by herbivorous species, suggesting that the fish population was relatively healthy. Carnivores were mostly represented by average-sized species of Lutjanidae and Lethrinidae. Herbivores were mostly represented by Acanthuridae, while Scaridae were quite rare. Size ratios were high for all families, being above 60% for all but Labridae. The very high percentage of hard bottom is favourable to herbivores, but here there was also a good presence of soft bottom, which usually supports certain species of carnivores.

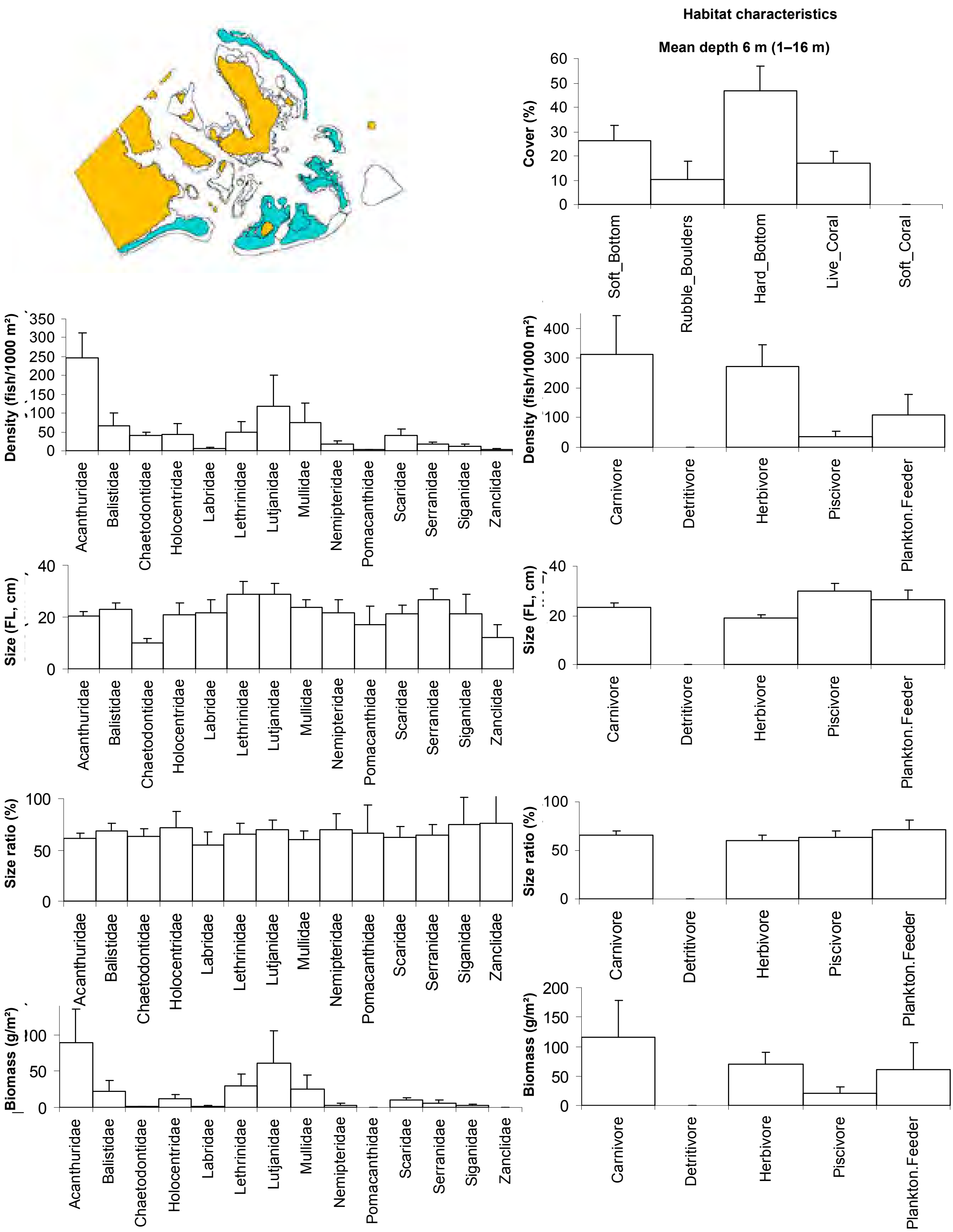

Figure 3.22: Profile of finfish resources in the back-reef environment of Marau.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Marau

The outer reef of Marau was dominated by the herbivores Acanthuridae and, to a much smaller extent, Scaridae. Carnivores, Lutjanidae and Lethrinidae, were important only in terms of biomass (Figure 3.23). These four families were represented by 38 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Acanthurus lineatus*, *Scarus psittacus*, *Monotaxis grandoculis*, *A. blochii*, *Lutjanus gibbus*, *Macolor macularis*, *Chlorurus sordidus* and *Naso vlamingii* (Table 3.10). Hard bottom (64% cover) largely dominated the habitat of this reef environment, which displayed a relatively good cover of live coral as well (24%, Table 3.6 and Figure 3.23). This type of substrate normally offers a perfect habitat for herbivorous families, here dominated by Acanthuridae.

Table 3.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Marau

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.16 ±0.06	14.3 ±5.8
	Acanthurus lineatus	Lined surgeonfish	0.06 ±0.05	16.3 ±13.7
	Acanthurus blochii	Ringtail surgeonfish	0.02 ±0.01	14.0 ±10.2
	Naso vlamingii	Bignose unicornfish	0.01 ±0.01	8.2 ±7.7
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.03 ±0.02	15.3 ±11.6
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.02 ±0.01	11.6 ±7.5
	Macolor macularis	Black snapper	0.02 ±0.01	12.4 ±7.9
Scaridae	*Scarus psittacus*	Common parrotfish	0.04 ±0.01	7.1 ±2.7
	Chlorurus sordidus	Daisy parrotfish	0.02 ±0.01	4.1 ±1.1

The biodiversity and density of finfish in the outer reef of Marau were the second-highest among the habitats of this site (51 species/transect and 0.7 fish/m^2, Table 3.6). Size, size ratio and biomass were the second-lowest values, below those of coastal and back-reefs, and only higher than lagoon-reef values. When comparing this outer reef to the other three sites, Marau displayed the highest average size, but density, size ratio and biomass were second to Nggela. Biodiversity was, however, the lowest among the four sites. Size ratios were lower than 50% for Kyphosidae, Labridae, Lethrinidae and Mullidae, suggesting some negative response from fishing. The trophic structure was clearly dominated by herbivores, in both number and biomass.

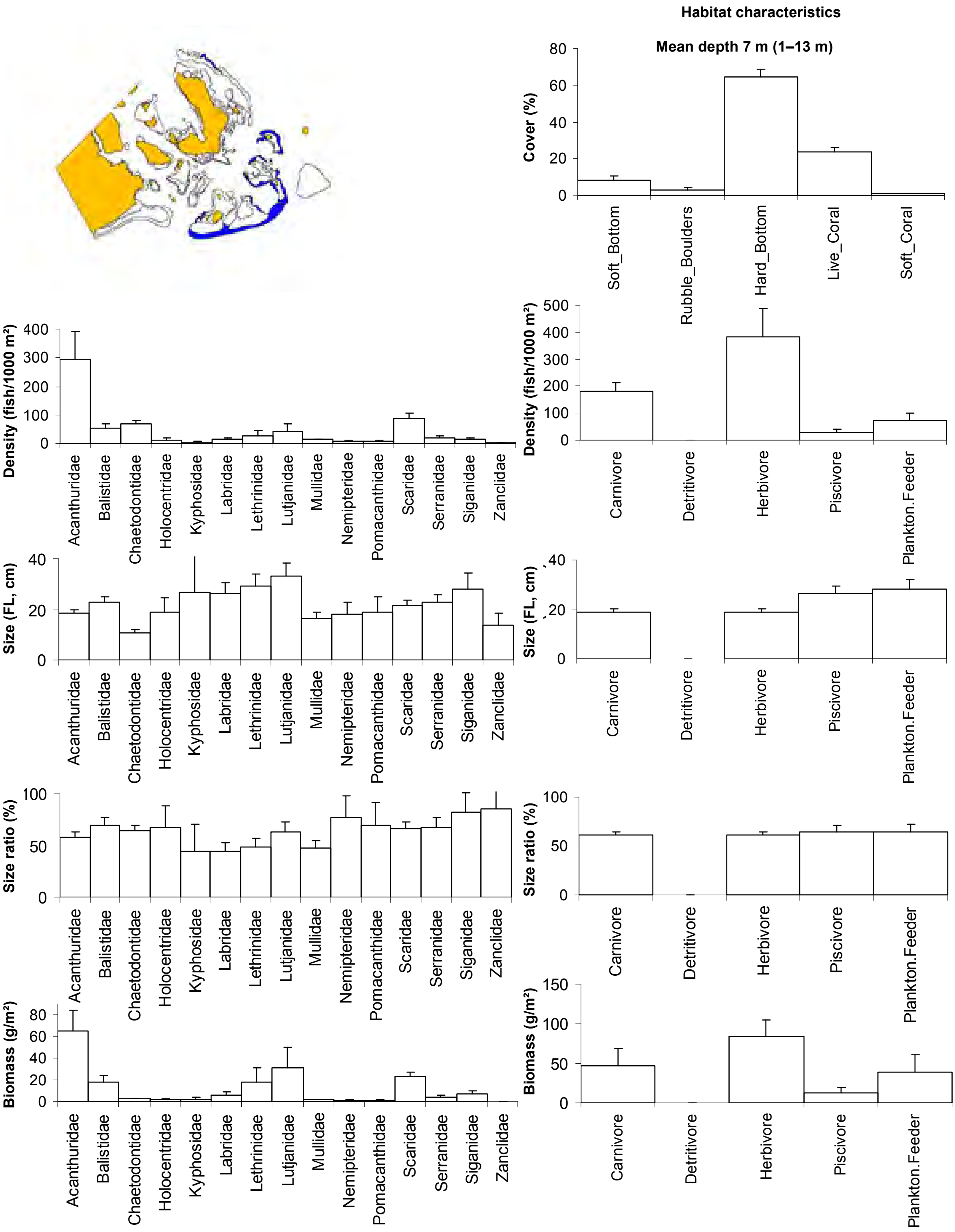

Figure 3.23: Profile of finfish resources in the outer-reef environment of Marau.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Marau

Overall, the fish assemblage of Marau was dominated by herbivorous Acanthuridae and, to a much lesser extent, Scaridae and carnivorous Lutjanidae, Lethrinidae and Mullidae (Figure 3.24). These four families were represented by a total of 72 species, dominated (in terms of density and biomass) by *Ctenochaetus striatus*, *Lutjanus gibbus*, *Acanthurus lineatus*, *A. pyroferus*, *A. olivaceus*, *Monotaxis grandoculis*, *Lutjanus lutjanus*, *Mulloidichthys flavolineatus*, *A. mata*, *A. blochii*, *M. vanicolensis* and *Gnathodentex aureolineatus* (Table 3.11). As expected, the overall fish assemblage in Marau shared characteristics of back-reefs (58% of total reef habitat), outer reefs (23%), lagoon reefs (17%) and to a smaller extent, coastal reefs (2%).

Table 3.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Marau (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.11	8.90
	Acanthurus lineatus	Lined surgeonfish	0.03	8.90
	Acanthurus pyroferus	Chocolate surgeonfish	0.02	3.29
	Acanthurus olivaceus	Orangeband surgeonfish	0.02	4.10
	Acanthurus mata	Elongate surgeonfish	0.01	17.64
	Acanthurus blochii	Ringtail surgeonfish	0.01	12.71
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.02	15.47
	Gnathodentex aureolineatus	Goldlined seabream	0.01	5.48
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.04	24.14
	Lutjanus lutjanus	Bigeye snapper	0.02	3.85
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.02	5.80
	Mulloidichthys vanicolensis	Yellowfin goatfish	0.01	7.39

Overall, Marau appeared to support a much higher finfish resource than the other sites, with highest value of average density (0.7 fish/m^2), size (21 cm FL), size ratio (63%) and biomass (224 g/m^2), and second-highest value of biodiversity (47 species/transect). These results suggest that the finfish resource in Marau is in a fairly healthy state. Detailed assessment at trophic level revealed an only slight dominance of herbivorous fish in terms of abundance but a dominance of carnivores in terms of biomass. Size ratio was in general high for most families, with only Kyphosidae being below 50% of the maximum size. In general, the substrate was dominated by hard bottom (average 52%) but displayed also a good cover of soft bottom (20%) and live coral (20%).

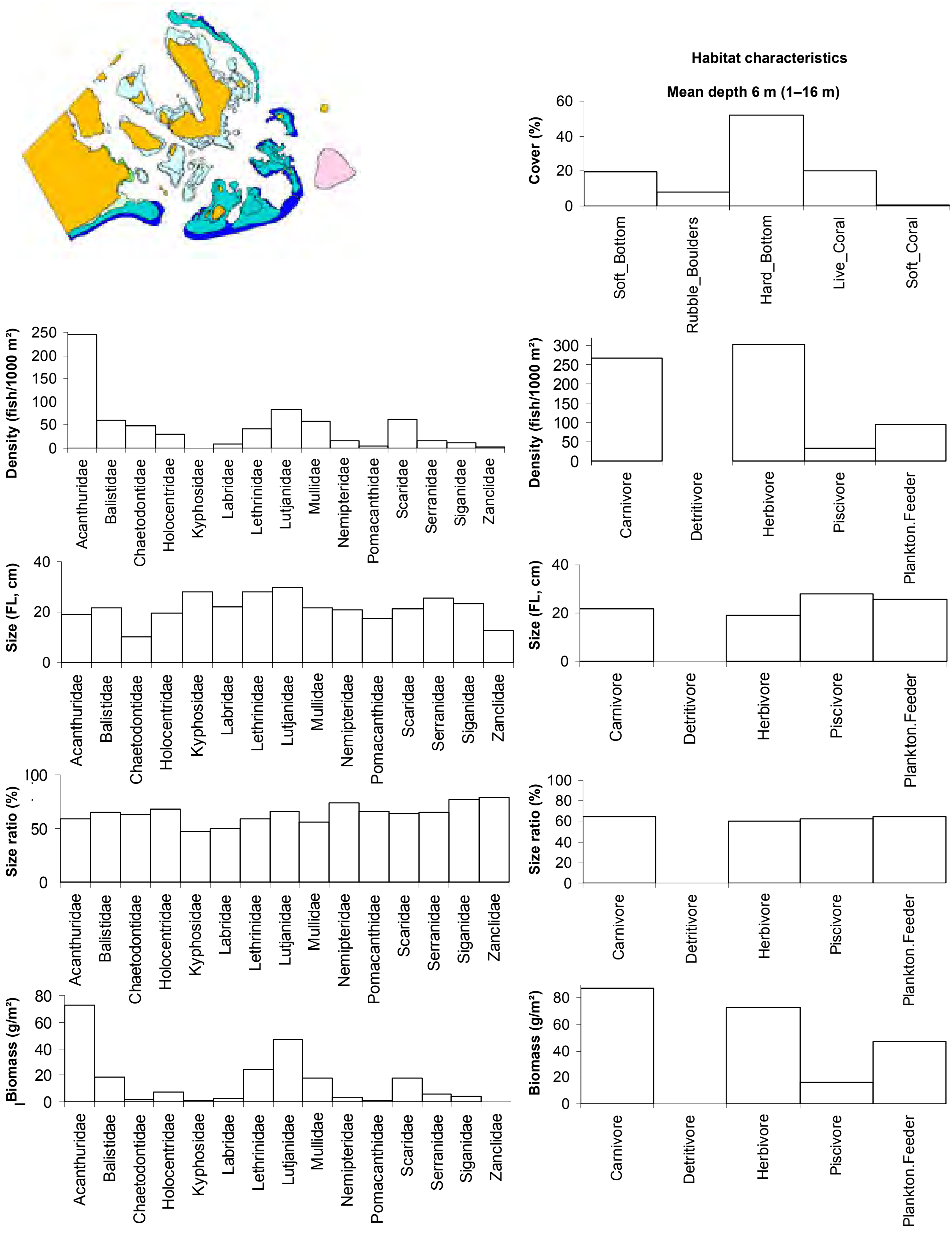

Figure 3.24: Profile of finfish resources in the combined reef habitats of Marau (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Marau

The assessment indicated that the status of finfish resources in Marau is better than in the other PROCFish sites surveyed, with highest values of fish density, average sizes and biomass. Moreover, the trophic composition displayed a good representation of carnivores, more important than herbivores in terms of biomass. Lutjanidae, Lethrinidae and Mullidae were present in good numbers in all reef habitats. Preliminary results suggest that this trend could be due to less-than-average impact from fishing, especially on carnivorous species. Herbivores were dominated by Acanthuridae, while Scaridae were relatively low in abundance. Even the average sizes of fish in the different habitats appeared to be large, a further indication that resources here are healthy. The healthiest habitat was found to be the back-reefs. The intermediate reefs showed the first signs of decrease in resources with smaller fish sizes and lower density.

- Overall, Marau finfish resources appeared to be in good condition. The reef habitat is relatively rich and supports fairly diverse finfish resources.

- Populations of snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) were systematically important. On the other hand, groupers (Serranidae) were much rarer.

3.4 Invertebrate resource surveys: Marau

The diversity and abundance of invertebrate species at Marau were independently determined using a range of survey techniques (Table 3.12): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 3.25) and finer-scale assessment of specific reef and benthic habitats (Figures 3.26 and 3.27).

The main objective of the broad-scale assessment is to describe the distribution pattern of invertebrates (rareness/commonness, patchiness) at large scale and, importantly, to identify target areas for further, fine-scale assessment. Then, fine-scale assessment is conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 3.12: Number of stations and replicate measures completed at Marau

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	12	72 transects
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	6	36 transects
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	4	24 search periods
Reef-front search by walking (RFs_w)	4	24 search periods
Sea cucumber day searches (Ds)	5	30 search periods
Sea cucumber night searches (Ns)	2	12 search periods

Figure 3.25: Broad-scale survey stations for invertebrates in Marau.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 3.26: Fine-scale reef-benthos transect survey stations and soft-benthos transect survey stations for invertebrates in Marau.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

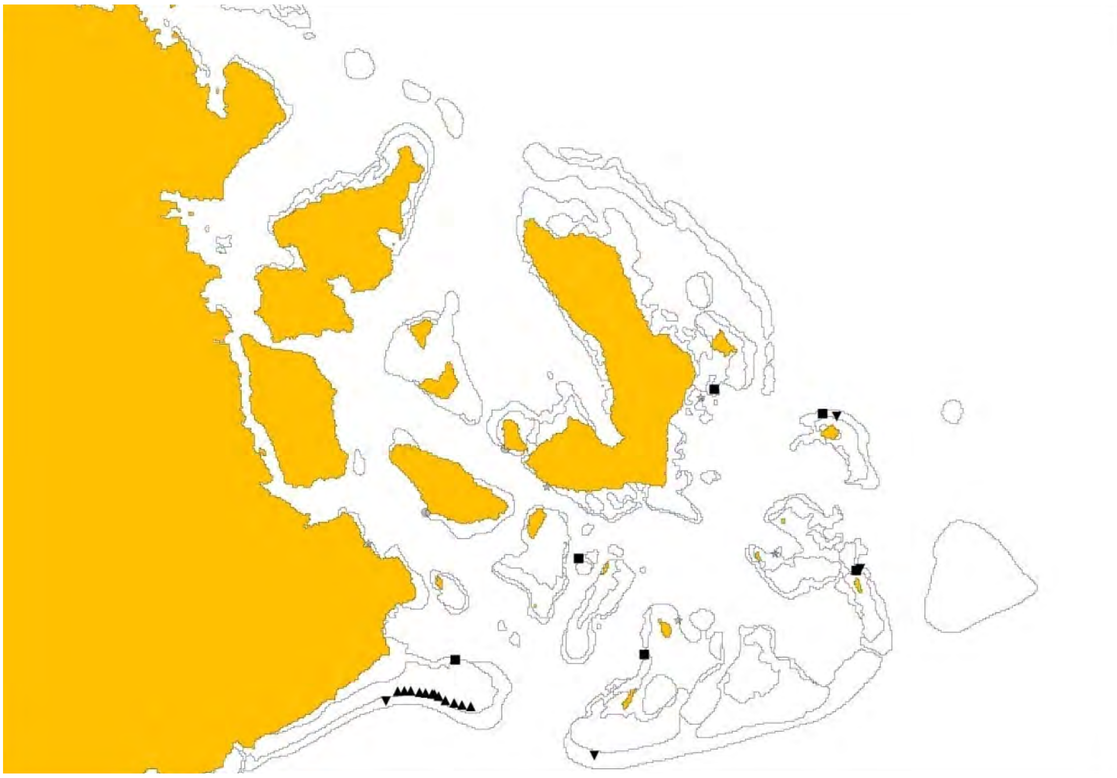

Figure 3.27: Fine-scale survey stations for invertebrates in Marau.
Inverted black triangles: reef-front search stations (RFs);
black squares: mother-of-pearl transect stations (MOPt);
grey circles: sea cucumber night search stations (Ns);
grey stars: sea cucumber day search stations (Ds).

Eighty-four species or species groupings (groups of species within a genus) were recorded in the Marau invertebrate surveys. These included 16 bivalves, 32 gastropods, 16 sea cucumbers, 7 urchins, 5 sea stars, 1 cnidarian and 2 lobsters (Appendix 4.2.1). Information on key families and species is detailed below.

3.4.1 Giant clams: Marau

Broad-scale sampling provided an overview of giant clam distribution at Marau. Shallow-reef habitat that is suitable for giant clams was moderately large in scale (19.5 km^2: approximately 11.6 km^2 within the lagoon and 7.9 km^2 on the reef front or slope of the barrier). Marau bordered the high island of Guadalcanal (eastern point), but comprised a group of islands less influenced by inputs from the land. Land influences were noted, in the form of allochthonous inputs and nutrients, but were less obvious as one moved past Marapa and Niu Islands towards the barrier reef. In general, the lagoon at Marau comprised a number of moderately deep sections between islands with fringing and patch reef. The prevailing swells were from the northwest and didn't affect the site significantly but, nevertheless, water movement was dynamic across the barrier and through the numerous passes of the lagoon, especially the southeastern entrance (east of Lauvi Island).

Reefs at Marau held six species of giant clam: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the fluted clam *Tridacna squamosa*, the smooth clam *T. derasa*, the true giant clam *T. gigas*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. Records from broad-scale sampling revealed that *T. maxima* had the widest occurrence (found in 9 stations and 27 transects), followed by *T. crocea* (5 stations and 11 transects), *T. squamosa*, *T. gigas*, *T. derasa* and *H. hippopus* (all recorded in only 1 station and 1 transect). The average station density of the most common species, *T. maxima*, in broad-scale surveys was low, at 8.5 /ha ±2.2 (Figure 3.28).

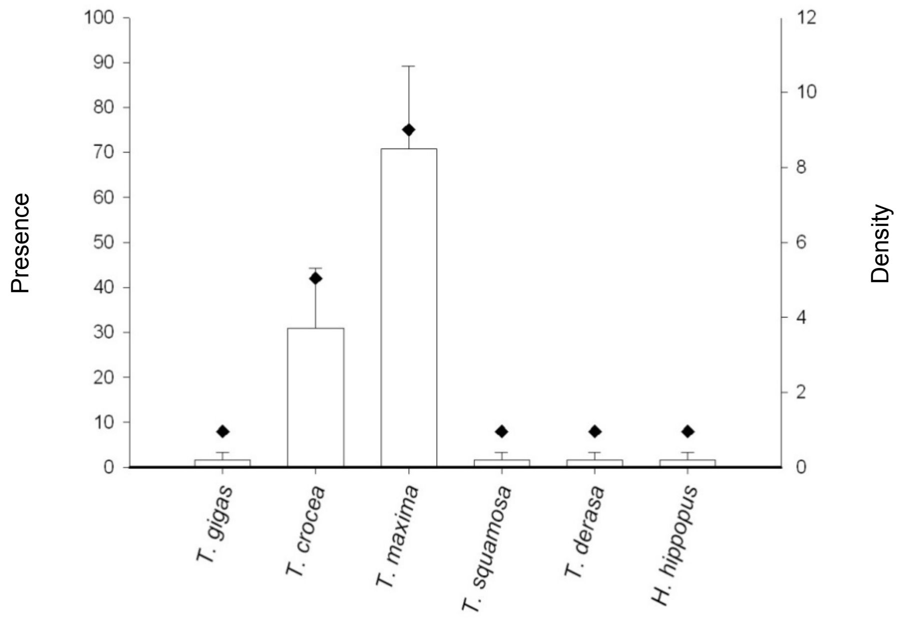

Figure 3.28: Presence and mean density of giant clam species in Marau based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 3.29). In these reef-benthos assessments (RBt), *T. maxima* was also present in 75% of stations at a mean density of 142.4 /ha ±52.7.

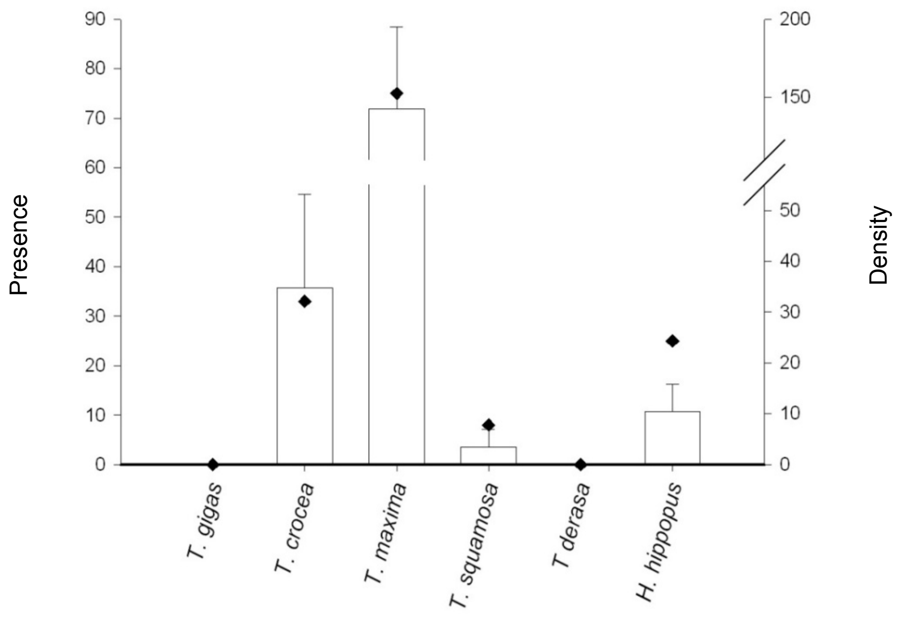

Figure 3.29: Presence and mean density of giant clam species in Marau based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

No clear picture emerged of where the highest-density areas of *T. maxima* were found with RBt station sampling. Shallow-reef areas below Niu Island and on reefs towards the barrier reef held *T. maxima* at station densities up to 200–650 /ha, but only 42% of stations had an average density of >100 clams/ha. The greatest density of clams per 40 m^2 transect in Marau was 1250 /ha, which represents just over 1 clam per 10 m^2. Three of the twelve stations situated close to settlements had zero densities in the records taken.

Of the 157 clam records (from all assessment methods), the average shell length of giant clam records was 13.4 cm ±0.6 for *T. maxima* (n = 111), 9.8 cm ±0.6 for *T. crocea* (n = 30), 23.8 cm ±3.1 for *T. squamosa* (n = 7) and 15.4 cm ±1.4 for *H. hippopus* (n = 7). In general, a full range of lengths were recorded for these species, although only a single juvenile *T. gigas* (16 cm length) and mid-sized *T. derasa* (22 cm) were noted.

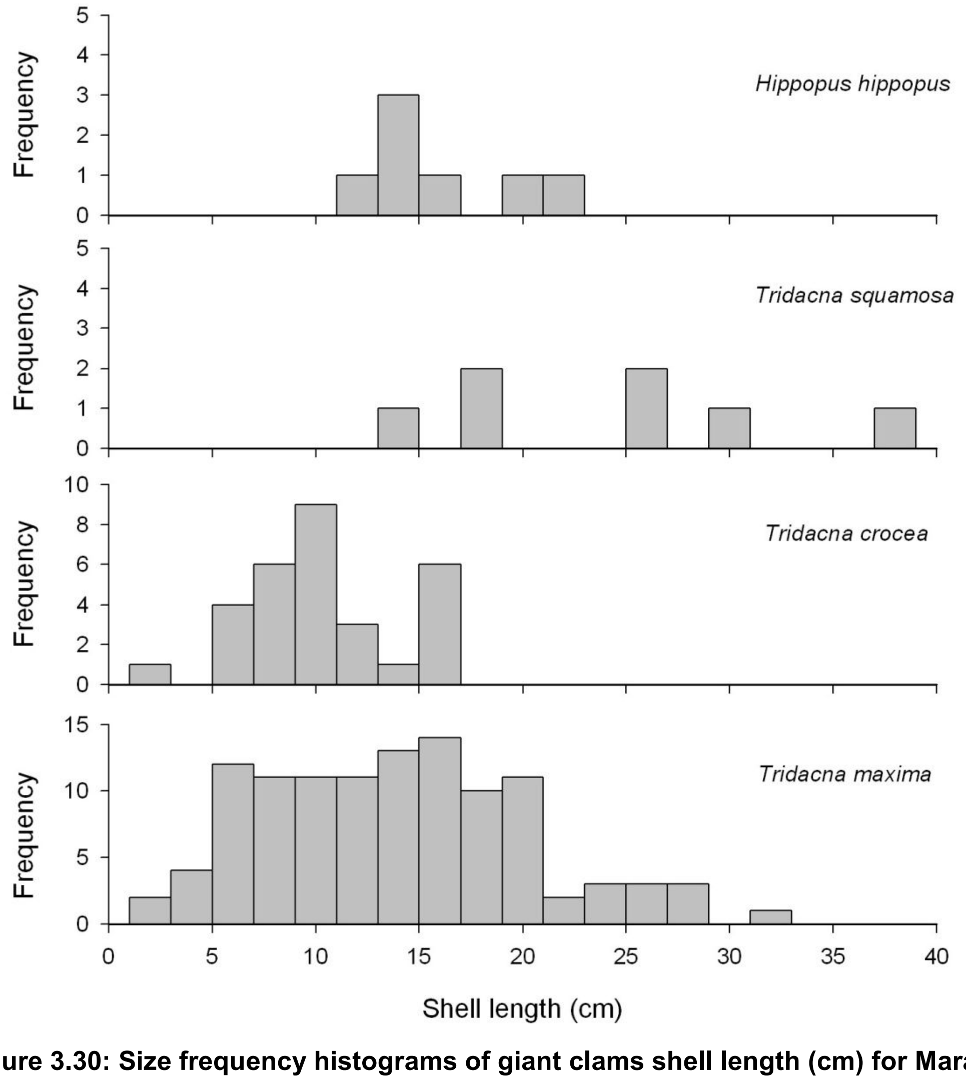

Figure 3.30: Size frequency histograms of giant clams shell length (cm) for Marau.

3.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Marau

Marau Sound lies well within the natural range of the commercial topshell, *Trochus niloticus*. Suitable reefs at Marau (16.1 km lineal distance of exposed reef perimeter) provide extensive benthos for *T. niloticus*, and both outer and inshore reefs were subject to dynamic water movement suitable for significant populations of trochus.

PROCFish/C survey work revealed that *T. niloticus* was relatively widespread across reefs in Marau, being present on both the barrier reef (outer reef slope and reeftop), on reefs within the passages and along the coast of the lagoon (Table 3.13).

Table 3.13: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Marau
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	3.5	1.6	5/12 = 42	8/72 = 11
RBt	20.8	8.1	5/12 = 42	6/72 = 8
SBt			0/12 = 0	0/72 = 0
RFs			0/4 = 0	0/24 = 0
RFs_w	0.6	0.6	¼ = 25	1/24 = 4
MOPt	13.9	13.9	1/6 = 17	2/36 = 6
Tectus pyramis				
B-S	0.5	0.3	2/12 = 17	2/72 = 3
RBt	222.2	33	11/12 = 92	41/72 = 57
SBt	59.0	37.1	3/12 = 25	3/72 = 4
RFs	11.8	3.6	4/4 = 100	8/24 = 33
RFs_w			0/4 = 0	0/24 = 0
MOPt	270.8	51.3	6/6 = 100	19/36 = 53
Pinctada margaritifera				
B-S	0.7	0.4	3/12 = 25	3/72 = 4
RBt	3.5	3.5	1/12 = 8	1/72 = 1
SBt	10.4	7.5	2/12 = 17	3/72 = 4
RFs			0/4 = 0	0/24 = 0
RFs_w			0/4 = 0	0/24 = 0
MOPt	27.8	17.6	2/6 = 33	2/36 = 6

B-S = broad-scale survey; RBt = reef-benthos transect; SBt = soft-benthos transect; RFs = reef-front search; RFs_w = reef-front search by walking; MOPt = mother-of-pearl transect.

Trochus were found at a few reef locations around Marau (total n = 24 individuals recorded) recorded from shoreline reefs (west of Maraubina Island) all the way to back-reefs behind the barrier (near Lauvi Island). In reef-front searches, trochus was not seen, although the closely related *Tectus pyramis* (with a similar life habit) was noted.

Despite the suitable habitat and wide distribution of trochus, the density of this commercial species at Marau was very low. No large aggregations were recorded, despite this broadcast spawner requiring males and females to be at high enough density to allow successful reproduction to take place. If the fisheries were to adopt a threshold of ~500 shells/ha as the minimum density required before main aggregations can be considered 'ready' for commercial fishing, the trochus density records from Marau indicated a significant shortfall in overall abundance.

Shell size also gives an important indication of the status of stocks by highlighting new recruitment into the fishery, or the lack of recruitment, which could have implications for the numbers of trochus entering the capture size classes in the following two years. The mean size (basal width) of trochus at Marau was 7.1 cm ±0.4 (n = 10).

No trochus were recorded below 5 cm (Figure 3.31). For this cryptic species, younger shells are normally only picked up in surveys from the size of about 5.5 cm, when small trochus are emerging from a cryptic phase of life to join the main stock. As can be seen from the length frequency graph, there are no small trochus or pulses of early adults entering the capture size classes of the fishery.

Young trochus enter the fishery stock at ~8 cm, when they are ~3 years old. Typically, trochus >11 cm are common in survey recordings, as these shells are less cryptic than smaller shells and, due to their prolific spawning potential, contribute greatly to future harvests (A trochus of 13 cm basal size produces three times the number of eggs produced by a trochus of 10 cm). In some well managed fisheries, shells >11 cm make up 20% of the measured stock. In figure 3.31, a dotted line highlights the 12 cm basal-size mark, when larger, mature size classes of shells would be protected from fishing under Solomon Islands regulations. It is obvious from these results that shells are not living to reach this size due to over fishing, or that trochus are being harvested at sizes larger than the legal limit.

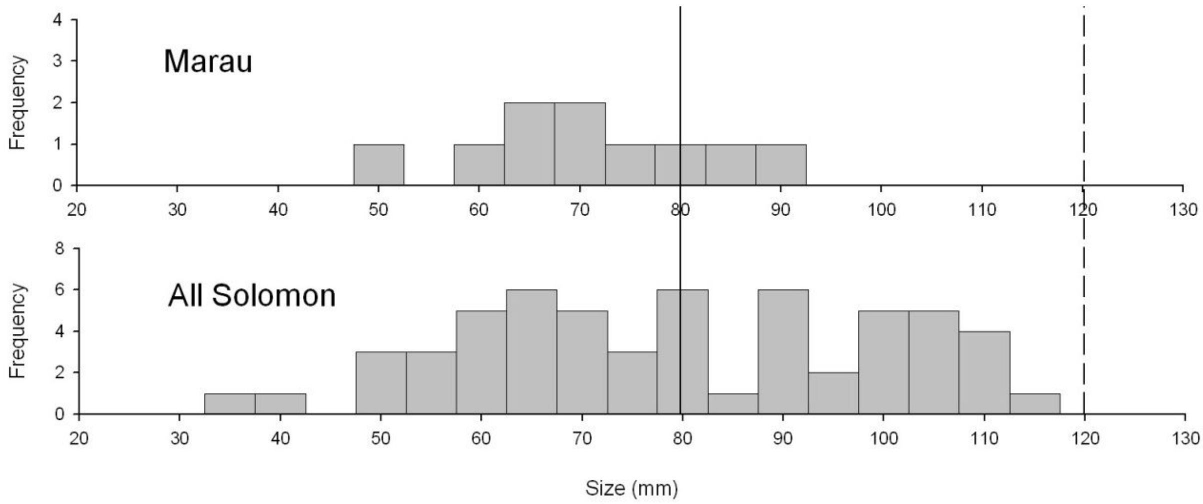

Figure 3.31: Size frequency histograms of trochus shell base diameter (cm) for Marau.

The suitability of reefs for grazing gastropods was highlighted by results for the false trochus or green topshell (*Tectus pyramis*). This related, but less valuable species of algal-grazing topshell was common (present in 92% of RBt stations) and at relatively high density (reaching a station average of >400 /ha).

No green snail, *Turbo marmoratus* were recorded in survey. This commercial species was common on the past, especially near the southeastern entrance (east of Lauvi Island), but according to Marau villagers, they have disappeared some 20 years ago (pers. comm. John Leqata).

Despite blacklip pearl oysters, *Pinctada margaritifera*, being cryptic and normally sparsely distributed in open lagoon systems, blacklip were relatively common in surveys (n = 12).

3.4.3 Infaunal species and groups: Marau

The soft-benthos coastal margin of the lagoon at Marau did not hold any notable concentrations of in-ground resources (shell 'beds'), such as arc shells (*Anadara* spp.) or venus shells, (*Gafrarium* spp.) Therefore, no infaunal stations (quadrat surveys) were made on soft benthos.

3.4.4 Other gastropods and bivalves: Marau

Seba's spider conch, *Lambis truncata* (the larger of the common spider conchs) was rare in surveys (only 1 individual recorded). *Lambis lambis* and the strawberry or red-lipped conch *Strombus luhuanus* were not very common either (recorded in 33% or less of RBt and SBt stations), reaching an average of <30 /ha. There was, however, a large range present (*L. chiragra*, *L. millepeda*, *S. lentiginosus*, *S. gibbosus*).

Out of the range of small turban shells (e.g. *Turbo argyrostomus*, *T. chrysostomus* and *T. setosus*), only *T. setosus* was recorded, at low density in shallow-reef stations (mean density 17.5 /ha ±9.7). It was not possible to closely inspect the surf zone at Marau as the swells made this work too dangerous; however, the species also did not show up in MOP surveys. Other resource species targeted by fishers (e.g. *Astralium*, *Cassis*, *Conus*, *Cypraea* and *Thais*) were also recorded during independent survey (Appendices 4.2.1 to 4.2.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Chama* and *Spondylus*, are also in Appendices 4.2.1 to 4.2.7. No creel survey was conducted at Marau.

3.4.5. Lobsters: Marau

Marau had 16.8 km (lineal distance) of exposed reef front (barrier reef). This exposed reef provided a suitable habitat for lobsters. Lobsters are an unusual invertebrate species, which can recruit from near and distant reefs as their larvae drift in the ocean for 6–12 months (up to 22 months) before settling as transparent miniature versions of the adult (pueruli, 20–30 mm in length).

There was no dedicated night reef-front work for the assessment of lobsters (See Methods.), but surveys still recorded ten *Panulirus versicolor* and two sand lobsters, the banded prawn killer *Lysiosquillina maculata.* Only one lobster was noted on night-time surveys targeting nocturnal sea cucumber species (Ns), and no slipper lobsters were noted.

3.4.6 Sea cucumbers[10]: Marau

Marau has a moderately extensive, shallow lagoon system bordering the large land mass of Guadalcanal. Fringing reef around islands, reef margins, and areas of shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) was present in abundance. There was significant land influence and riverine influence close to shore, but the lagoon, despite being well protected, was subject to dynamic water movement and flushing. The benthos was without heavy epiphytic growth and, in general, the system could be considered to be largely oceanic-influenced. Outside the barrier, the reef slope shelved relatively steeply, but banks of shallow reef (shoals) were located offshore.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 3.14, Appendices 4.2.2 to 4.2.9; also see Methods). At Marau, 16

[10] There has been a recent variation to sea cucumber taxonomy which has changed the name of the black teatfish in the Pacific from *Holothuria (Microthele) nobilis* to *H. whitmaei*. There is also the possibility of a future change in the white teatfish name. This should be noted when comparing texts, as in this report the 'original' taxonomic names are used.

commercial species of sea cucumber were recorded during in-water assessments, plus one indicator species (Table 3.14). The range of sea cucumber species recorded in Marau somewhat reflected the position of Solomon Islands, which is close to the centre of biodiversity. The varied nature of habitats at Marau (lagoon benthos, passages and outer reef) suited deposit-feeding sea cucumber species, which eat organic matter in the upper few mm of bottom substrates.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*), were not common in broad-scale surveys (recorded in 13% of transects). Average density records for this species, at <5 /ha in broad-scale and <21 /ha in RBt stations, suggest that stocks are under some pressure. Black teatfish (*Holothuria nobilis*) is a high-value species that is highly susceptible to over fishing and therefore provides a good indicator of fishing pressure when the distribution and density is known. This species was not common in general surveys (only recorded in 4% of broad-scale transects), but was picked up at a reasonable rate in reef-benthos transects (average density of 10.4 /ha), even though this species is usually recorded at low density (total of n = 12 individuals recorded in all surveys).

Notably, the fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was not found at any stations in Marau. Surf redfish (*Actinopyga mauritiana*), another easily targeted species, was rare at Marau and at low density when found. The highest-density areas of surf redfish recorded on the reeftop never exceeded 20 /ha. This species can be recorded at commercial densities of 500–600 /ha in other parts of Guadalcanal, and also in French Polynesia and Tonga.

In more protected areas of reef and soft benthos in partially enclosed areas of the lagoon, we did not record blackfish (*Actinopyga miliaris*), and curryfish (*Stichopus hermanni*) were rare. Even low-value lollyfish (*Holothuria atra*), pinkfish (*H. edulis*) and brown sandfish (*Bohadschia vitiensis*) were both uncommon and at low density. The premium-priced sandfish (*H. scabra*) was also recorded once in this survey (n = 1 individual, size ~14 cm). The record was not made within a survey transect, but was recorded as an observation on the south of Simeruka island (SBt 10). Earlier surveys (in 2004) had noted this species west of Marauiapa island (Ferral Lasi pers. comm.).

Deeper-water assessments (30 five-minute searches, average depth 19.8 m, maximum depth 24 m) were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), amberfish (*T. anax*) and partially for elephant trunkfish (*H. fuscopunctata*). Oceanic-influenced lagoon benthos near passages had suitably dynamic water movement for these species and *H. fuscogilva* was relatively common in three of the five deep-water stations surveyed. Interestingly, relatively high numbers of white teatfish were recorded in a number of other more shallow-water surveys (total n = 29 individuals recorded in all surveys). In these recordings, white teatfish was at moderate density (<20 individuals/ha). Interestingly, the more common, lower-value deep-water species amberfish (*T. anax*) was not recorded in survey.

3.4.7 Other echinoderms: Marau

On soft benthos, the edible collector urchin (*Tripneustes gratilla*) was common (recorded in 75% of SBt stations) and at high density (mean density 357.6 ±138.3, n = 103). Slate urchins (*Heterocentrotus mammillatus*) were uncommon but large, black *Echinothrix* spp. (also edible and a habitat-indicator species) were both common (recorded in 75% of broad-scale and 83% of RBt stations) and in dense patches (up to 500 /ha in broad-scale stations and 4000 /ha in RBt stations). *Echinometra mathaei* and *Diadema* spp. were commonly noted (See Appendices 4.2.1 to 4.2.7).

Starfish were commonly distributed around Marau; the blue starfish (*Linckia laevigata*) was recorded in large numbers (n = 499) and was common across broad-scale surveys (recorded in 100% of broad-scale stations and 72% of replicates). Pincushion stars (*Culcita novaeguineae*) were noted at 67% of broad-scale stations, but not at high density (6.5 /ha ±2.2). Forty-two records of another coralivore (coral-eating) starfish, the crown of thorns star (*Acanthaster planci*, COTS) were noted. Its presence was concentrated on reefs near Tawaihi Island and reefs near Niu Island and to the west of the southeastern entrance (See presence and density estimates in Appendices 4.2.1 to 4.2.7.). This level of colonisation is not an outbreak, but is of concern as COTS can consume significant amounts of live coral (2–6 m^2 of coral/year). Although no outbreaks were recorded in survey, some sections of reef outside survey stations did have a very high density (e.g. the southwest reef of Tawaihi island).

3.4.8 Discussion and conclusions: invertebrate resources in Marau

A summary of environmental, stock-status and management factors for the main fisheries is given below. Please note that information on other, smaller fisheries and the status of less prominent species groups can be found in the body of the invertebrate chapter.

In summary, habitat, giant clam distribution, density and shell length information revealed that:

- The sheltered lagoon reef at Marau, with its complex structure (inshore, intermediate and barrier) and dynamic water movement was very suitable for giant clams.

- Giant clam presence was moderate, but density was in general low considering the suitability of the environment. The elongate clam, *Tridacna maxima*, had the highest density, but its coverage and aggregations were unremarkable. In addition, the other species present at Marau were also relatively rare, and at lower-than-expected densities. Both *T. derasa* and *T. gigas*, which are critically depleted in many parts of the Pacific, were 'commercially extinct'[11] in Marau.

- Although *T. maxima*, *T. crocea* and *T. squamosa* displayed a relatively 'full' range of size classes, including young clams (which indicate successful spawning and recruitment), the abundance of clams close to shore, and of large clams, was relatively low. This information, in addition to the low abundance and density, suggest that giant clams in Marau are heavily impacted by fishing.

Data on MOP distribution, density and shell size suggest the following:

- Local reef conditions at Marau provide an extensive and good habitat for juvenile and adult trochus. Trochus had a wide distribution at easily accessible reefs including exposed barrier reeftop, although no trochus aggregations were identified outside the barrier reef.

[11] Commercially extinct means in this context that the clams were at such a low density as to make them unavailable for any trade and in danger of complete local extinction.

- Size class information reveals that no strong year class is currently visible below the commercial size class range, and that previous harvests have comprehensively fished the stock. Most eggs are produced by the largest individuals of the population, and trochus only reach these size classes at ≥6 years of age (from shells that would need to survive at least three years in the fishery under the current management scenario). The current population has very few large, old shells (>11 cm basal width), which have the greatest potential to release the eggs and sperm to fuel future populations to support the fishery.

- The low commercial value green topshell, *Tectus pyramis*, and blacklip pearl oyster, *Pinctada margaritifera*, were relatively common at Marau.

- The green snail (*Turbo marmoratus*), a native species commonly found in Marau on past surveys, was not recorded in this survey. No dead shells were seen onshore and this species is considered as commercially extinct in Marau.

In summary, the distribution, density and length recordings of sea cucumbers at Marau reveal the following:

- Although commercial sea cucumber species at Marau were numerous (n = 16), the range of sea cucumbers present at this site was not as high as expected for its varied habitat and biogeographical position.

- Distribution data showed that sea cucumbers were well spread across the site, although medium- and high-value commercial species, such as the leopard or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*) were not common. Unusually, low-value species, such as lollyfish (*H. atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*), were not common.

- The low density of most sea cucumber species and species groups suggests that the fishery has little potential for further harvesting at this time.

- The oceanic nature of the area and its dynamic water movement suited the high-value, deeper-water white teatfish (*Holothuria fuscogilva*). This species was moderately common in Marau and suggests that, with careful management of harvests, a small regular harvest of this species is possible in Marau.

Table 3.14: Sea cucumber species records for Marau

Species	Common name	Commercial value [5]	B-S transects n = 72			Reef and soft benthos stations RBt = 12; SBt = 12			Other stations RFs = 4; RFs_w = 4; MOPt = 6			Other stations Ds = 5; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H				3.5	41.7	8 SBt						
Actinopyga lecanora	Stonefish	M/H				3.5	41.7	8 RBt	6.9	41.7	17 MOPt			
Actinopyga mauritiana	Surf redfish	M/H							7.1	9.5	75 RFs_w			
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	3.0	24.1	13	20.8 6.9	62.5 41.7	33 RBt 17 SBt	6.9	41.7	17 MOPt	22.2 0.7	22.2 3.6	100 Ns 20 Ds
Bohadschia graeffei	Flowerfish	L	1.6	23.3	7	6.9 3.5	41.7 41.7	17 RBt 8 SBt	6.9	41.7	17 MOPt	8.9 0.7	17.8 3.6	50 Ns 20 Ds
Bohadschia similis	False sandfish	L				69.4	416.7	17 SBt						
Bohadschia vitiensis	Brown sandfish	L				13.9	55.6	25 SBt				4.4	8.9	50 Ns
Holothuria atra	Lollyfish	L	6.2	27.9	22	48.6 13.9	145.8 83.3	33 RBt 17 SBt	69.6	69.6	100 RFs_w	8.9	17.8	50 Ns
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L	0.2	16.7	1							17.8 0.7	35.6 3.6	50 Ns 20 Ds
Holothuria fuscogilva [4]	White teatfish	H	1.4	20.0	7	6.9 17.4	83.3 104.2	8 RBt 17 SBt				4.4 10.7	8.9 17.8	50 Ns 60 Ds
Holothuria fuscopunctata	Elephant trunkfish	M				3.5	41.7	8				2.9	7.1	40 Ds
Holothuria nobilis [4]	Black teatfish	H	0.7	16.7	4	10.4 3.5	83.3 41.7	17 RBt 8 SBt				13.3 1.4	13.3 7.1	100 Ns 20 Ds
Holothuria scabra	Sandfish	H												
Stichopus chloronotus	Greenfish	H/M												
Stichopus hermanni	Curryfish	H/M										4.4	8.9	50 Ns
Stichopus horrens	Peanutfish	M/L				3.5	41.7	8 RBt				17.8	35.6	50 Ns
Stichopus vastus	Brown curryfish	H/M												
Synapta spp.	-	-												
Thelenota ananas	Prickly redfish	H	0.7	16.0	4				6.9	41.7	17 MOPt			
Thelenota anax	Amberfish	M												

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) *nobilis* to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published. [5] L = low value; M = medium value; H= high value; H/M is higher in value than M/H; B-S transects= broad-scale transects; RBt = reef-benthos transect; SBt = soft-benthos transect; RFs = reef-front search; RFs_w = reef-front search by walking; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

3.5 Overall recommendations for Marau

- Community fisheries management projects need to be continued and improved, with a precautionary approach to resource use. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Marau fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- Pressure on some finfish resources is already high, and high also on at least a number of invertebrate species. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

- Intermediate reefs were the poorest of the four habitats present and increase in finfish fishing should be avoided in this reef. However, further development of reef fish fisheries, especially in back-reefs and coastal reefs, could be sustainable if accompanied by appropriate management and regular monitoring to follow the response of resources.

- Cooperation among governmental, NGOs and other external institutions, and the community needs to be sought in order to ensure the success of improved fisheries management.

- For successful stock management, giant clams need to be maintained at higher density and include larger-sized individuals, to ensure there is sufficient spawning taking place to produce new generations.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha.

- Management arrangements need to be developed and implemented for sea cucumbers given the low densities of most species.

4. PROFILE AND RESULTS FOR RARUMANA

4.1 Site characteristics

Rarumana is located on Parara Island in Western Province (Figure 4.1). The Rarumana community consists of a number of villages which are scattered along the coastal fringe of the northern part of Parara Island. The population of the community is estimated to be more than 1000 in 2006. Most members of the community belong to the United Church. Our survey work was conducted on islets and reefs inside the lagoon surrounding the community. There is strong water exchange from the ocean with the lagoon, resulting in moderately clear lagoonal waters. Consequently, there is an absence of mangrove forest on the site surveyed, except for areas on the borders and bays that are outside of the study areas. Reef flats in Rarumana tend to be narrower in width. Exceptions are the outer reefs which are much wider (100–300 m). There was good coral cover and growth especially in the mid and outer part of the lagoon.

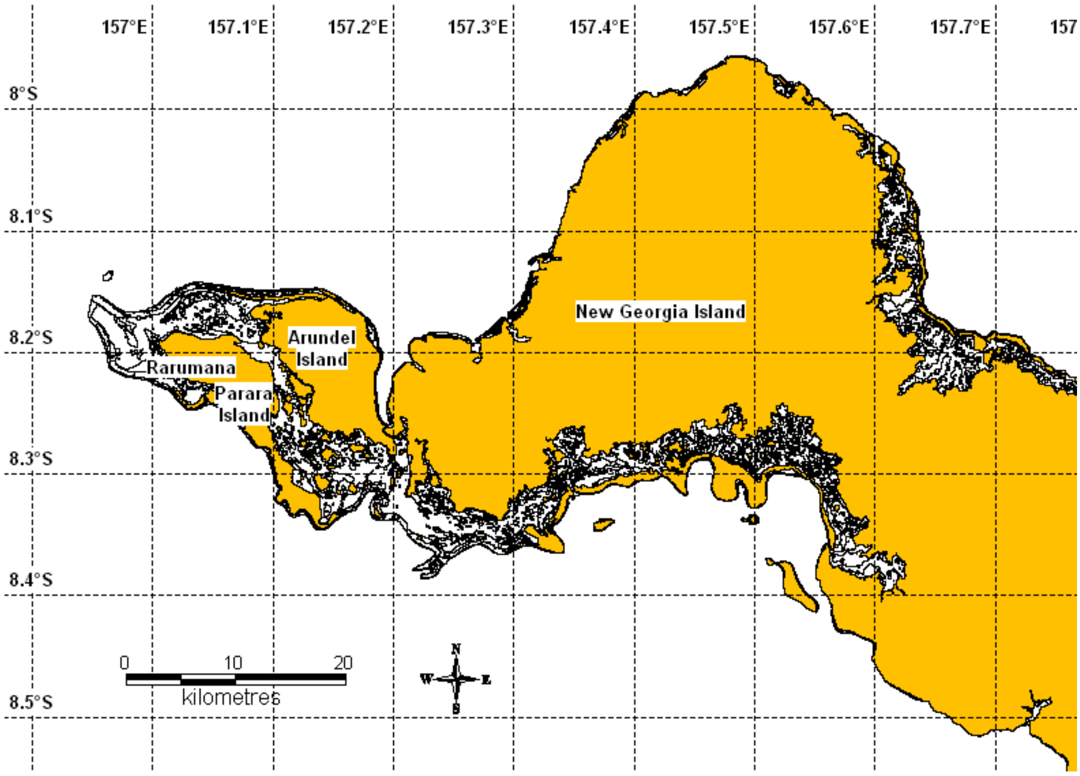

Figure 4.1: Map of Rarumana.

4.2 Socioeconomic surveys: Rarumana

Socioeconomic fieldwork was carried out in Rarumana on Parara Island in the Western Province of Solomon Islands on 8–17 August 2006. There are several villages and settlements on the island, and four of these were surveyed. The results presented in the following are referred to as 'Rarumana'. There are two main customary divisions on the island, each being under the authority of a chief. However, some small villages on the island live according to their own traditional arrangements. Any of the traditional structures is overwritten by the dominating Wesley United Church and, to a much lesser extent, the Catholic and Seventh Day Adventist churches. All people are engaged in one of these three churches and village life is organised around religious obligations and beliefs. Particularly the females on Rarumana belong to church groups, which perform community work.

Rarumana has very limited access to market seafood. The nearest market centre is Gizo, which has already sufficient fish supply from communities closer by. The small market volume available and the transport costs make Gizo an unattractive market to fishers from Rarumana. The major market for seafood, Honiara, is far away and the transport cost is high. Small market outlets for selling fish and invertebrates within the island were affected by the tsunami that hit Gizo in 2006. Other income sources from fisheries are no longer possible, be it the bêche-de-mer fishery, which is subject to national temporary ban, or the aquarium-trade fishery, which is banned due to an ongoing court case. Fisheries produce is therefore only sold on a small-scale, either by door-to-door selling of fresh or cooked fish and invertebrates on the island, or selling to the logging companies in the area.

Logging activities that take place on the island provide the local population with access to timber. As a result, most people live in large, wooden houses. Also, due to the availability of wood, canoes are widespread throughout the community. During the survey, 95 canoes and 12 motorised boats were counted in 50 households surveyed. Some people also use 15–25 hp outboard engines on their wooden canoes. Canoes are the main means of transport to reach agricultural production sites for travel and also for fishing. People have plentiful access to farm land that is made available through tribal or, in places, clan-owned land. Land ownership is regulated along matrilineal lines, however, the influence and authority within villages is in the hands of males.

The survey included four smaller villages. The total population was 1803 people. The survey included 41 households, i.e. ~15% of the total number of households (280). All (100%) of the surveyed households are engaged in some form of fishing activities. In addition, a total of 61 finfish fishers (41 males and 20 females) and 70 invertebrate fishers (34 males and 36 females) were interviewed. The average household size is six people; however, the range observed over the four villages was 3–9 people per household. Household interviews focused on the collection of general demographic, socioeconomic and consumption data.

4.2.1 The role of fisheries in the Rarumana community: fishery demographics, income and seafood consumption patterns

Our results (Figure 4.2) suggest that agriculture, notably copra, provides the most important income opportunities for the people of Rarumana. As first income, agriculture plays the most important role for ~49% of all households and as secondary income for another ~37% of all households. Fisheries take the same, comparatively low, role as other income sources, i.e. 17% as first, and 17% as second income. Other sources include small-business activities, such as bread making, the selling of cooked food, canteens, lime and betel nut sale. As observed elsewhere, salaries play only a minor role, i.e. only 12% of households rely on salaries as first income. Only 25% of all households have a pig, and ~27% of all households may have one or two chickens.

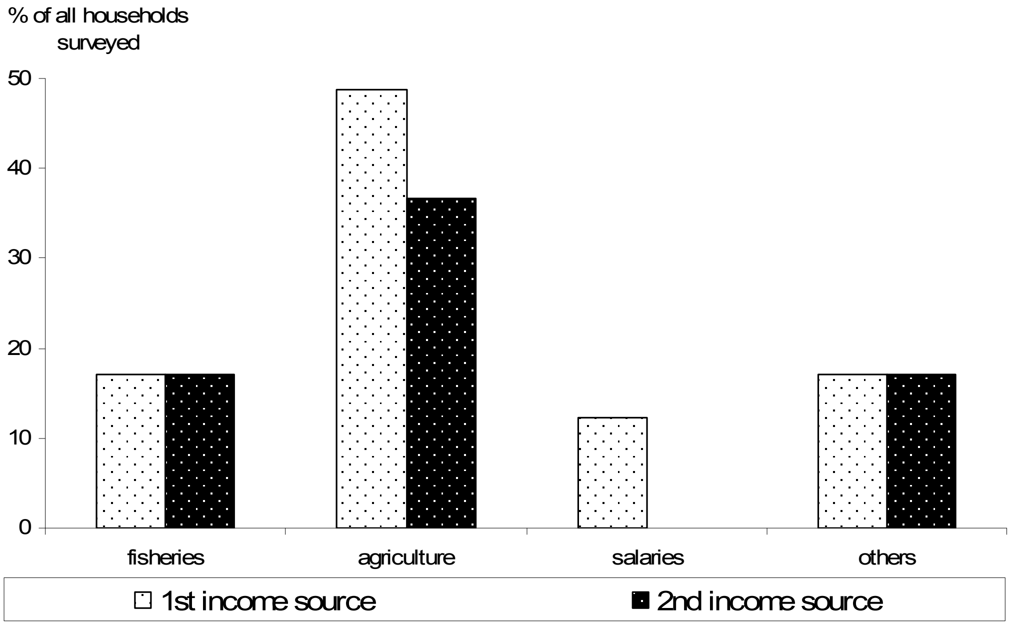

Figure 4.2: Ranked sources of income (%) in Rarumana.
Total number of households = 41 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small business.

Our results (Table 4.1) show that annual household expenditures are low, with an average of USD 387, and slightly below the average across all four sites investigated in Solomon Islands. One-quarter of all households receive remittances. These are on average about USD 234 /year, representing 60% of the average household expenditure. Remittances are usually sent from family members who live and work in Honiara.

Survey results indicate an average of three fishers per household and, when extrapolated, the total number of fishers in Rarumana is 895 including 519 males and 376 females. Among these are 144 exclusive finfish fishers (137 males, 7 females), 20 exclusive invertebrate fishers (females only), and 731 fishers who fish for both finfish and invertebrates (383 males, 348 females). Almost all households (90%) own a boat. Most (~95%) are non-motorised canoes; only ~5% are equipped with an outboard engine.

Table 4.1: Fishery demography, income and seafood consumption patterns in Rarumana

Survey coverage	Site (n=41 HH)	Average across sites (n=182 HH)
Demography		
HH involved in reef fisheries (%)	100.0	99.5
Number of fishers per HH	3.20 (±0.19)	3.24 (±0.12)
Male finfish fishers per HH (%)	15.3	17.0
Female finfish fishers per HH (%)	0.8	2.2
Male invertebrate fishers per HH (%)	0.0	0.2
Female invertebrate fishers per HH (%)	2.3	9.0
Male finfish and invertebrate fishers per HH (%)	42.7	39.6
Female finfish and invertebrate fishers per HH (%)	38.9	32.1
Income		
HH with fisheries as 1st income (%)	17.1	30.2
HH with fisheries as 2nd income (%)	17.1	32.4
HH with agriculture as 1st income (%)	48.8	33.5
HH with agriculture as 2nd income (%)	36.6	31.9
HH with salary as 1st income (%)	12.2	11.0
HH with salary as 2nd income (%)	0.0	0.5
HH with other source as 1st income (%)	17.1	24.2
HH with other source as 2nd income (%)	17.1	12.1
Expenditure (USD/year/HH)	386.62 (±50.72)	404.22 (±22.58)
Remittance (USD/year/HH) (1)	234.05 (±51.58)	258.35 (±55.85)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	110.91 (±9.99)	104.78 (±4.00)
Frequency fresh fish consumed (times/week)	3.46 (±0.08)	3.57 (±0.05)
Quantity fresh invertebrate consumed (kg/capita/year)	9.81 (±1.37)	10.13 (±4.00)
Frequency fresh invertebrate consumed (times/week)	1.34 (±0.13)	1.20 (±0.06)
Quantity canned fish consumed (kg/capita/year)	3.77 (±0.72)	3.75 (±0.34)
Frequency canned fish consumed (times/week)	0.91 (±0.13)	0.85 (±0.07)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	97.6	95.6
HH eat canned fish (%)	85.4	75.3
HH eat fresh fish they catch (%)	97.6	97.6
HH eat fresh fish they buy (%)	14.6	21.4
HH eat fresh fish they are given (%)	73.2	71.4
HH eat fresh invertebrates they catch (%)	90.2	71.4
HH eat fresh invertebrates they buy (%)	2.4	0.0
HH eat fresh invertebrates they are given (%)	56.1	47.6

HH = household; (1) average sum for households that receive remittances; numbers in brackets are standard error.

Consumption of fresh fish is high with ~111 kg/person/year, which is slightly higher than the average across all four study sites in Solomon Islands, and also significantly higher than the assumed average for Solomon Islands of 40 kg (Gillet and Lightfoot 2001) to 45.5 kg/person/year (FAO 2008), or the regional average of ~35 kg/person/year (Figure 4.3). By comparison, consumption of invertebrates (edible meat weight only) (Figure 4.4) is similar to the average across all other sites with 9.8 kg/person/year. Canned fish (Table 4.1) adds only 3.8 kg/person/year to the protein supply from seafood. The consumption pattern of seafood found in Rarumana highlights the fact that people have access to agricultural and fishery resources. People produce crops and catch enough fish to be self-sufficient in food. Frozen foods or other imported food is hardly ever consumed due to the limited cash income and thus purchasing power, and the lack of electricity and ice-making facilities.

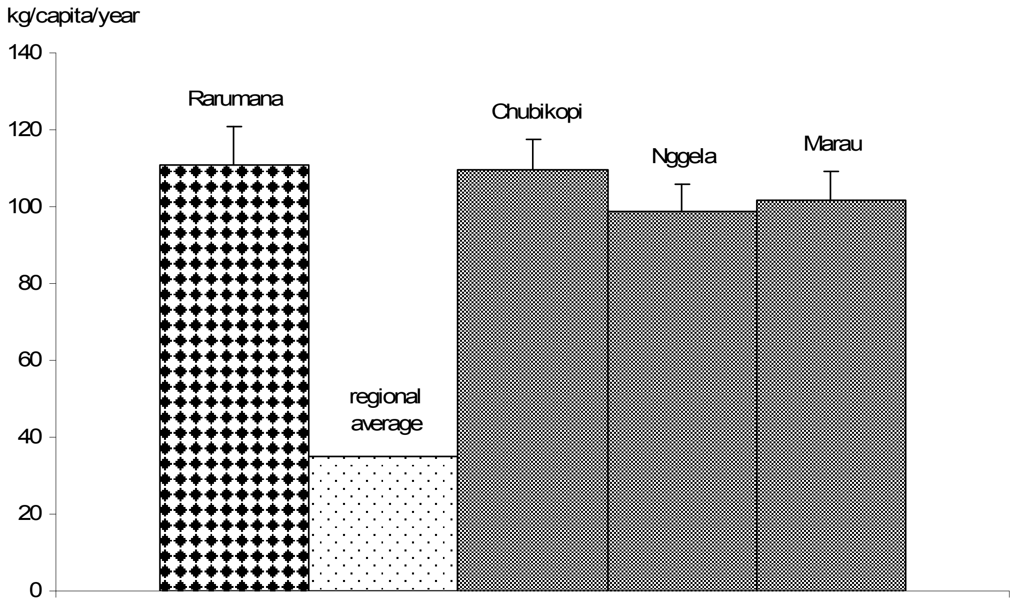

Figure 4.3: Per capita consumption (kg/year) of fresh fish in Rarumana (n = 41) compared to the regional average (FAO 2008) and the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

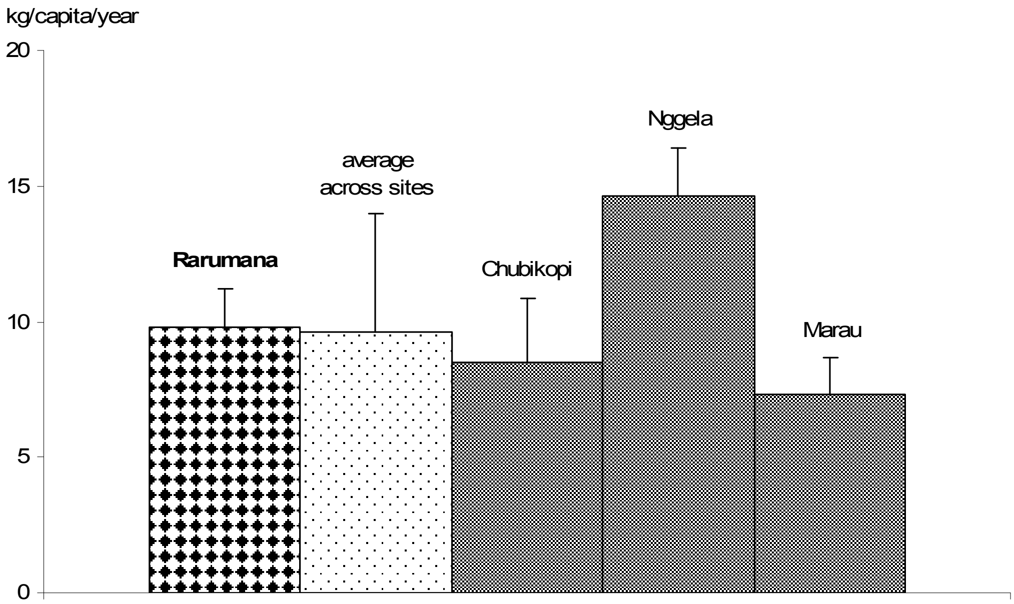

Figure 4.4: Per capita consumption (kg/year) of invertebrates (meat only) in Rarumana (n = 41) compared to the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results obtained for Rarumana to the average figures across all four study sites surveyed in Solomon Islands, people of the community eat fresh fish, invertebrates and canned fish about as often as found on average. However, while they eat slightly more fresh fish, they eat about average quantities of invertebrates. Rarumana people consume, buy, or eat seafood that is caught by somebody living in the household about as much as the average found in all study sites. Sharing seafood among community members on a non-monetary basis is very common, and more practised for invertebrates than observed elsewhere. Income from fisheries plays a much lesser role and from agriculture a much greater role than elsewhere, which income may highlight the fact that Rarumana has very little access to marketing catches. Few people are engaged in handicrafts or small businesses, and very few benefit from salaries. By comparison, slightly more people in Rarumana own boats than elsewhere and slightly more of these than average are non-motorised.

4.2.2 Fishing strategies and gear: Rarumana

In Solomon Islands, the management of marine resources is usually divided between the governmental legal and the traditional village system. However, in the case of Rarumana, no fisheries management interventions were found to be in place. There were also no traditional regulations on the use of fisheries resources. On the other hand, people expressed concern about the observed decreases in fish sizes, longer time needed to catch the same amount of fish that they previously caught in a shorter time, and also poaching by external fishers who serve the Gizo market.

Fishing is one of the most important sources of protein and calories. Fisheries produce is also important for social cohesion, as it is regularly exchanged among community members as a gift. Although marketing possibilities are limited, seafood also helps to generate income on Rarumana Island. Traditional gender roles do not apply to fishing but tradition demands for labour to be shared by both males and females.

However, there is a split between male and female fishers' engagement in fisheries, as found elsewhere in the Pacific, with almost no females fishing exclusively for finfish, and only females fishing exclusively for invertebrates. However, these groups of fishers who exclusively target either finfish or invertebrates are only small proportions of the total fishing community. Most fishers, males and females, fish for both invertebrates and finfish (Figure 4.5). Children also participate in subsistence fisheries on a regular basis, mostly during school holidays and on weekends; while accompanying their parents they learn traditional skills and knowledge.

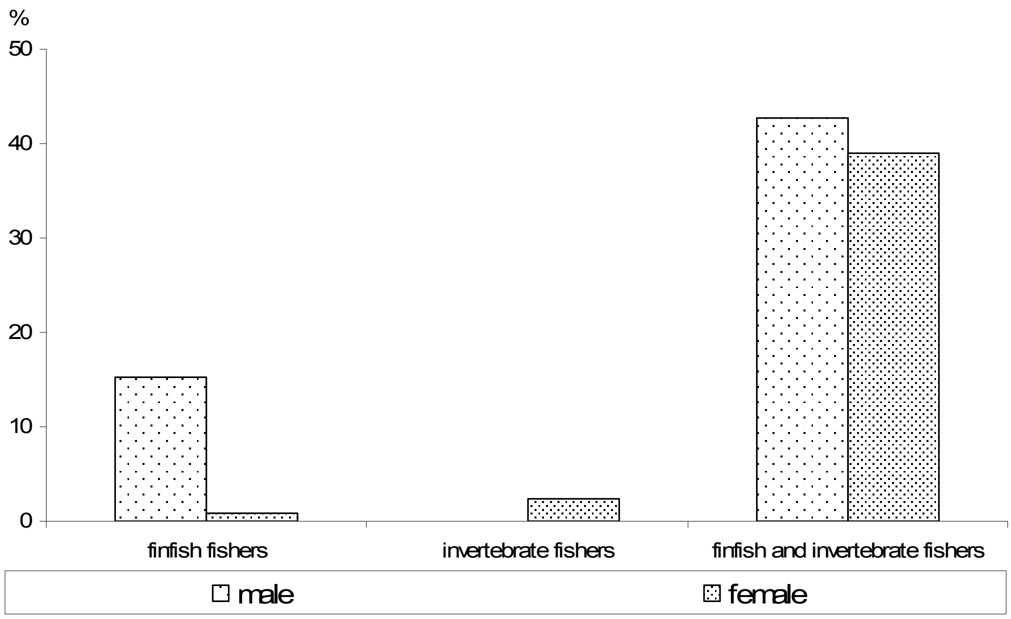

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Rarumana.
All fishers = 100%.

Targeted stocks/habitat

Boats, here mainly non-motorised canoes, are essential for transportation, gardening and fishing. Most fishing is done in the sheltered coastal areas and lagoon (by ~85% of all male fishers and 100% of female fishers). If the outer reef is targeted, travel time is longer, exposure to sea and weather conditions is higher, often motorised boats are used and only males (~12%) target these habitats. Table 4.2 also shows that the community has access to a great number of habitats that support a great variety of invertebrates. Usually fishers visit a combination of several habitats during one fishing trip. The reeftop and diving fisheries for mainly giant clams and lobsters ('other') attract most male fishers (~53%) and ~16% of all female fishers. Most females (~70%) glean mangroves and soft benthos. All other fisheries, including lobster and trochus, that may be predominantly commercial are not much pursued. This underlines the limited marketing options for fishers in Rarumana.

Table 4.2: Proportion (%) of interviewed male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Rarumana

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	9.8	30.0
	Sheltered coastal reef & lagoon	75.6	65.0
	Sheltered coastal reef & lagoon & outer reef	2.4	0.0
	Lagoon	0.0	5.0
	Lagoon & outer reef	2.4	0.0
	Outer reef	12.2	0.0
Invertebrates	Reeftop	0.0	2.8
	Reeftop & other	52.9	13.9
	Reeftop & trochus & other	8.8	0.0
	Intertidal & reeftop	0.0	41.7
	Intertidal & reeftop & other	11.8	27.8
	Soft benthos & mangrove	5.9	69.4
	Soft benthos & intertidal & reeftop	0.0	2.8
	Soft benthos & intertidal & reeftop & other	8.8	11.1
	Mangrove	8.8	27.8
	Lobster	14.7	0.0
	Trochus & other	5.9	0.0
	Other	11.8	0.0

'Other' refers to the giant clam and trochus fisheries.
Finfish fisher interviews, males: n = 41; females: n = 20. Invertebrate fisher interviews, males: n = 34; females: n = 36.

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip are the basic factors to estimate the fishing pressure imposed by people from Rarumana on their fishing grounds (Tables 4.2 and 4.3).

Our survey sample suggests that fishers from Rarumana have a good choice among sheltered coastal reef, lagoon and outer reef fishing, including passages. There are also a number of fishers who venture out for oceanic fishing; however, this is not the subject of this study. As mentioned above, the same is true for invertebrate collection as the community has access to intertidal, soft benthos, reeftop, lagoon and mangrove areas (Figure 4.6). 'Other', representing 22% of the invertebrate fishery, is basically diving for giant clams and trochus. Gender separation only shows in the fact that females do not particularly choose diving for invertebrates as an exclusive fishery. This fishery, including lobster, trochus and 'other' (giant clams, trochus) fishing, and a combination thereof, is performed by males. However, female fishers of Rarumana do dive, but only in combination with gleaning and other collection methods (Figure 4.7).

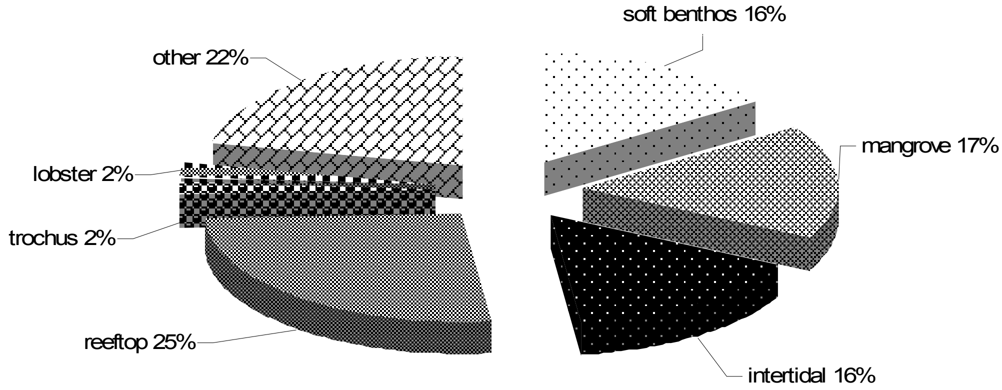

Figure 4.6: Proportion (%) of fishers targeting the seven primary invertebrate habitats found in Rarumana.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the giant clam and trochus fisheries.

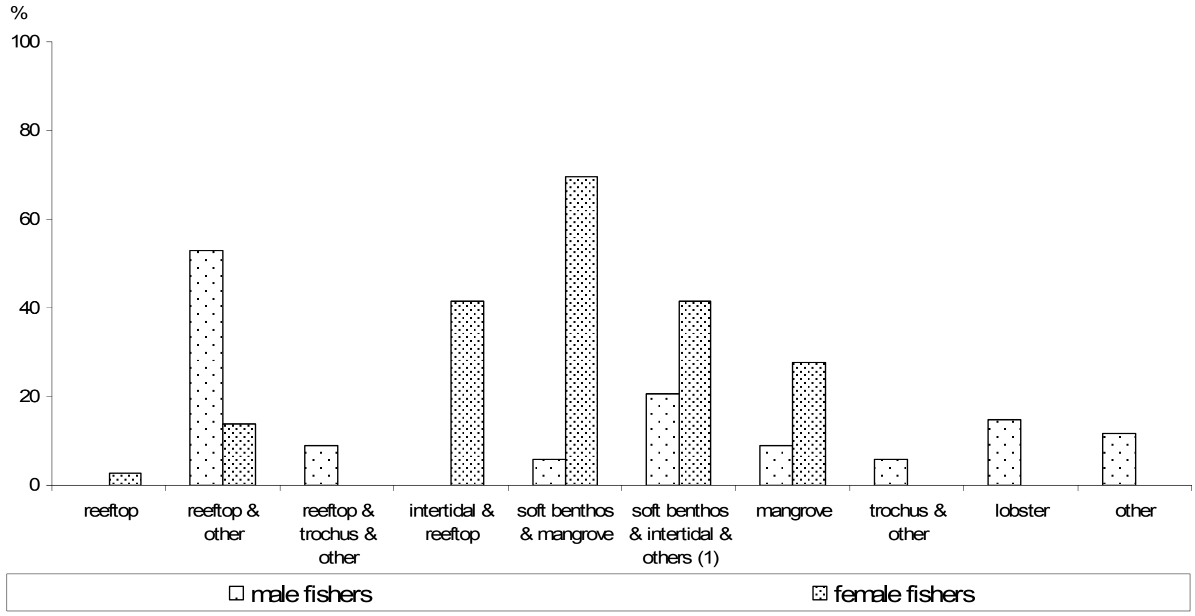

Figure 4.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Rarumana.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 34 for males, n = 36 for females; 'other' refers to the giant clam and trochus fisheries; 'others (1)' refer to intertidal and/or reeftop and/or 'other'.

Gear

Figure 4.8 shows that Rarumana fishers use a variety of different gear, that they may combine different fishing techniques if catching fish in a particular habitat, and that low-cost fishing equipment is mostly used. For all habitats, handlining and spear diving are the dominant techniques. Castnets, or castnets in combination with fishing rods, gillnets or handlines, as well as the exclusive use of gillnets, are seldom used. At the outer reef, and in conjunction with pelagic fishing activities, also deep-bottom lines and trolling are common (Figure 4.8).

Concerning invertebrate collection, most activities involve very simple techniques, such as digging, collecting by hand or netting in tidal pools, seagrass beds and sand and mud flats, as well as in mangroves, using sticks, knives and other available tools.

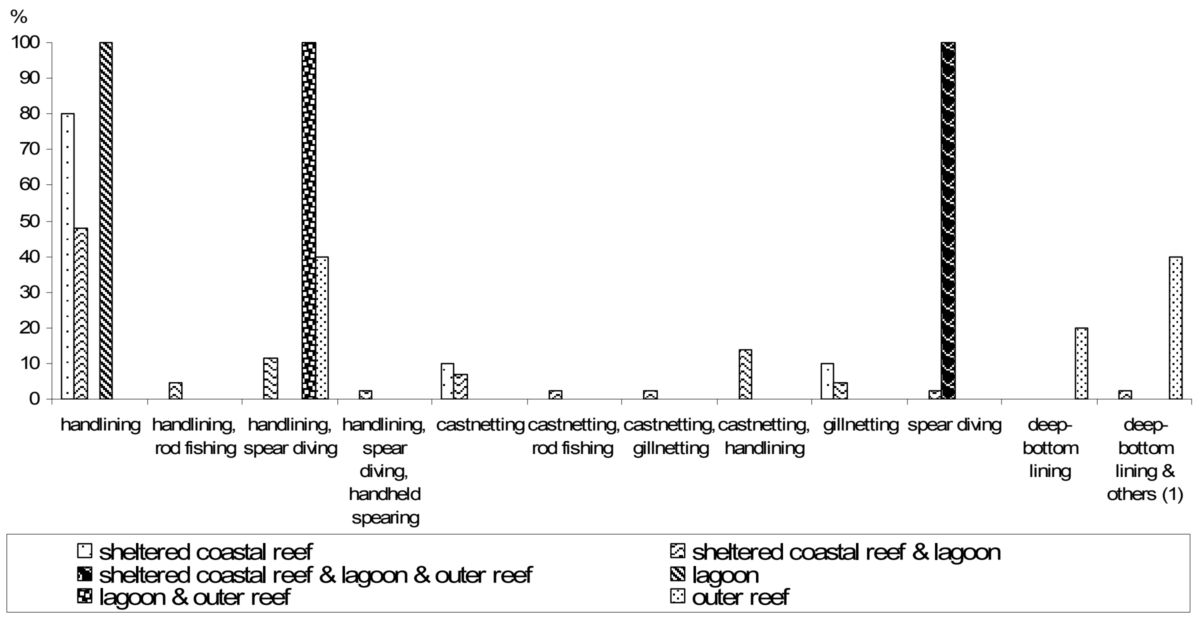

Figure 4.8: Fishing methods commonly used in different habitat types in Rarumana.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.
Deep-bottom lining & others (1): handlining, trolling, handheld spearing and spear diving.

Frequency and duration of fishing trips

Male and female fishers go finfish fishing to any of the finfish habitats ~1–2 times/week. As shown in Table 4.3, the fact that an average fishing trip takes longer targeting the outer reef or a combination of lagoon and outer reef (5–6 hours) may explain why females fish in the habitats closer to shore. Here, there is no marked difference between gender groups, both spend on an average ~3–4 hours per fishing trip.

Invertebrate harvesting is performed less frequently than finfish fishing. Both male and female fishers harvest invertebrates about once a week. There seems to be no marked difference in the frequency of trips to habitats that are more exploited than others. This observation applies for male and female fishers. There is also no significant difference in the duration of an average invertebrate fishing trip. Both male and female fishers spend an average of 3–4 hours. Soft-benthos and mangrove gleaning may take a little longer, i.e. up to 5 hours if done by female fishers (Table 4.3).

The frequency and duration of fishing trips may also be determined by the use of boats. Canoes are used for most finfish fishing trips closer to shore and canoes and motorised boats are used for outer-reef and passage fishing trips. Boats may also be borrowed from other community members. Most finfish fishing is done during the day and tidal conditions are the most important factor for choosing the right time to fish at the outer reef. The preference for daytime fishing is very much influenced by the threat of crocodiles. This applies in particular to areas close to or inside mangrove swamps and habitats closer to shore. Finfish fishing is performed throughout the year and combined and interwoven with agricultural activities. The use of ice during fishing trips is not a standard practice, but ice is often used on fishing trips targeting the sheltered coastal reef and lagoon. As elsewhere, the purchase of ice, if available at all, is difficult; the lack of electricity in the communities may be one of the major reasons.

Almost all invertebrate collection is done using a canoe to reach the fishing ground or to support the diving and collection activities. Usually, invertebrates are collected all year round with no particular season. Almost all activities are exclusively performed during the day, but most lobster diving (80%) is undertaken at night. The presence of crocodiles is the major reason for the almost exclusive daytime fishing, in particular in mangrove areas and muddy water.

Table 4.3: Average frequency and duration of fishing trips reported by male and female fishers in Rarumana

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.63 (±0.24)	2.50 (±0.32)	3.25 (±0.48)	3.17 (±0.17)
	Sheltered coastal reef & lagoon	2.35 (±0.11)	1.96 (±0.12)	3.39 (±0.10)	4.00 (±0.69)
	Sheltered coastal reef & lagoon & outer reef	1.50 (n/a)	0	4.00 (n/a)	0
	Lagoon	0	4.00 (n/a)	0	4.00 (n/a)
	Lagoon & outer reef	1.50 (n/a)	0	5.00 (n/a)	0
	Outer reef	1.80 (±0.12)	0	5.40 (±0.40)	0
Invertebrates	Reeftop	0	1.00 (n/a)	0	4.00 (n/a)
	Reeftop & other	1.00 (±0.10)	0.90 (±0.10)	3.17 (±0.09)	3.00 (±0.00)
	Reeftop & trochus & other	1.17 (±0.17)	0	3.67 (±0.33)	0
	Intertidal & reeftop	0	0.98 (±0.13)	0	3.60 (±0.13)
	Intertidal & reeftop & other	1.50 (±0.29)	1.30 (±0.15)	3.50 (±0.50)	3.20 (±0.13)
	Soft benthos & mangrove	0.85 (±0.15)	1.13 (±0.11)	4.00 (±0.00)	4.56 (±0.15)
	Soft benthos & intertidal & reeftop	0	2.00 (n/a)	0	4.00 (n/a)
	Soft benthos & intertidal & reeftop & other	1.23 (±0.40)	1.50 (±0.29)	3.67 (±0.33)	4.00 (±0.00)
	Mangrove	0.73 (±0.15)	1.17 (±0.14)	4.33 (±0.88)	5.00 (±0.30)
	Lobster	0.48 (±0.14)	0	4.80 (±0.37)	0
	Trochus & other	1.00 (±0.00)	0	3.00 (±0.00)	0
	Other	1.00 (±0.00)	0	2.50 (±0.29)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and trochus fisheries.
Finfish fisher interviews, males: n = 41; females: n = 20. Invertebrate fisher interviews, males: n = 34; females: n = 36.

4.2.3 Catch composition and volume – finfish: Rarumana

The catches reported from the sheltered coastal reef alone are not very diverse and determined to a great extent (~56%) by five species groups only, including Scaridae, Lethrinidae, Balistidae and Lutjanidae. The combined fishing of sheltered coastal reef and lagoon renders the most diverse catches, with basically two species groups, notably Lutjanidae and Lethrinidae, determining 20% and ~24% respectively of the reported catch. Scaridae play a lesser role, with about 8% of the total average annual reported catch. As for sheltered coastal reef catches, exclusive lagoon catches include mostly Lutjanidae, Lethrinidae and Scaridae. If the outer reef is targeted, either alone or in combination with the lagoon, in addition to these three families, also Serranidae, Labridae and, not surprisingly, Carangidae make up a more important part of the reported catch. Detailed information on catch composition by species, species groups and habitats are reported in Appendix 2.3.1.

Figure 4.9 highlights findings from the socioeconomic survey reported earlier, that finfish fishing serves mainly subsistence purposes and, due to the lack of important market channels, plays only a minor role in income generation. The total annual catch is estimated to amount to ~281 t, of which >61% is used for subsistence needs, while ~39 % is sold either locally to other communities on the island, to logging companies, or to Gizo and the Honiara market. While participation in finfish fishing did not vary much between gender groups, male fishers account for 74% of the total catch, while female fishers provide ~26% only. As reported earlier, the preference of female fishers to fish closer to shore also shows in the accumulated impact of both gender groups, i.e. ~86% of the total impact is imposed on the sheltered coastal reef and lagoon resources. The remaining ~14% is on outer-reef resources, either exclusively targeted (~11%) or in combination with resources closer to shore.

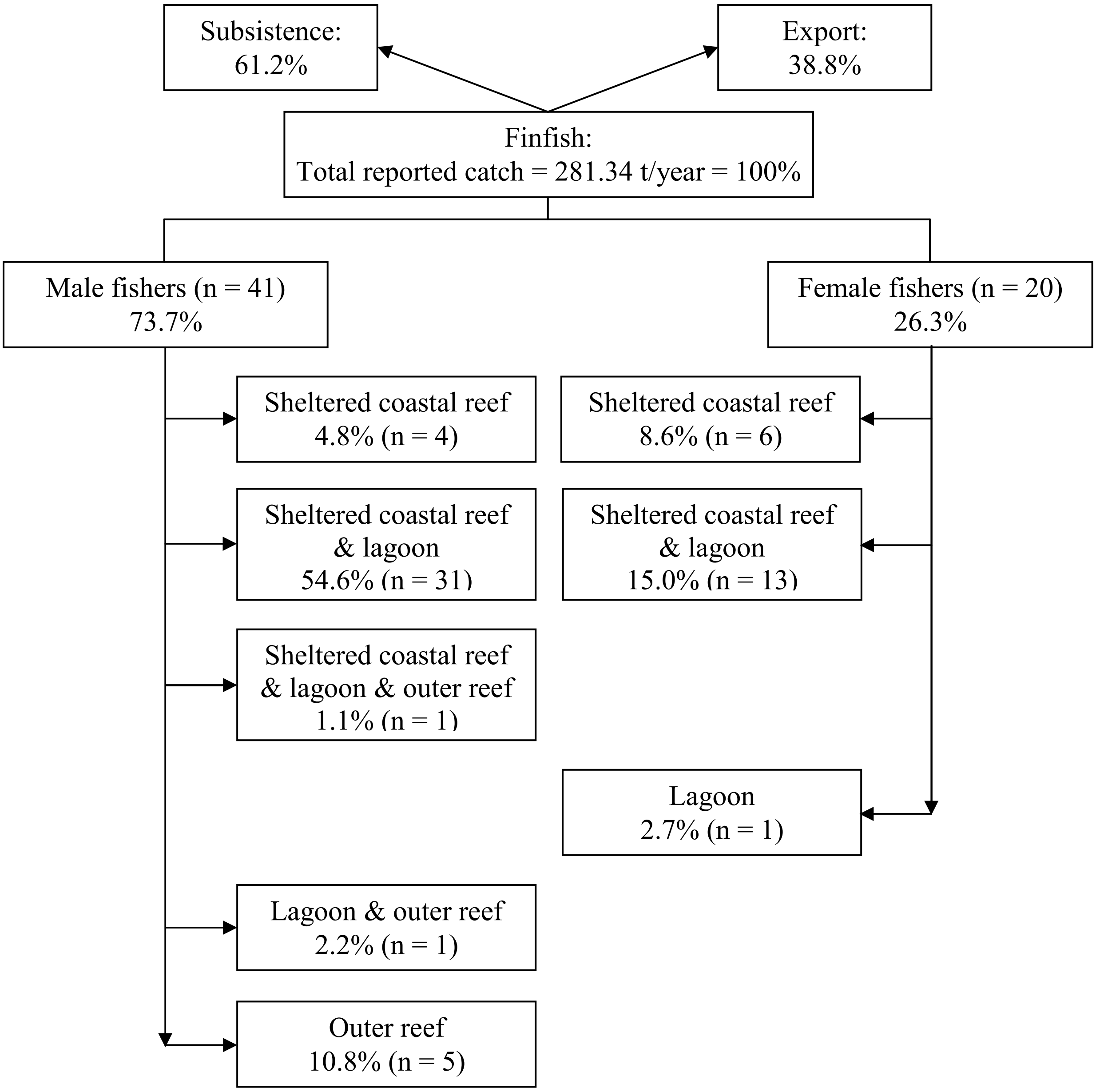

Figure 4.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Rarumana.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The distribution of annual catch weight between the easier accessible sheltered coastal reef and lagoon areas and the more distant outer reef is a consequence of the much larger number of fishers targeting closer-to-shore habitats than the outer reef. As shown in Figure 4.10, the average annual catch per fisher does vary substantially between areas closer to shore and the outer reef. While the average annual catch per fisher targeting the sheltered coastal reef alone or in combination with the lagoon amounts to ~250–350 kg, the combined fishing of lagoon and outer reef, or outer-reef fishing alone, renders about >450 kg/fisher/year on average. The difference in the average annual catch between male and female fishers is also not pronounced if comparing figures for the same habitats fished, i.e. the combined sheltered coastal reef and lagoon areas. While female fishers seem to catch slightly more than males on an annual average from the sheltered coastal reef, they catch less than males if the sheltered coastal reef and the lagoon are combined in one fishing trip.

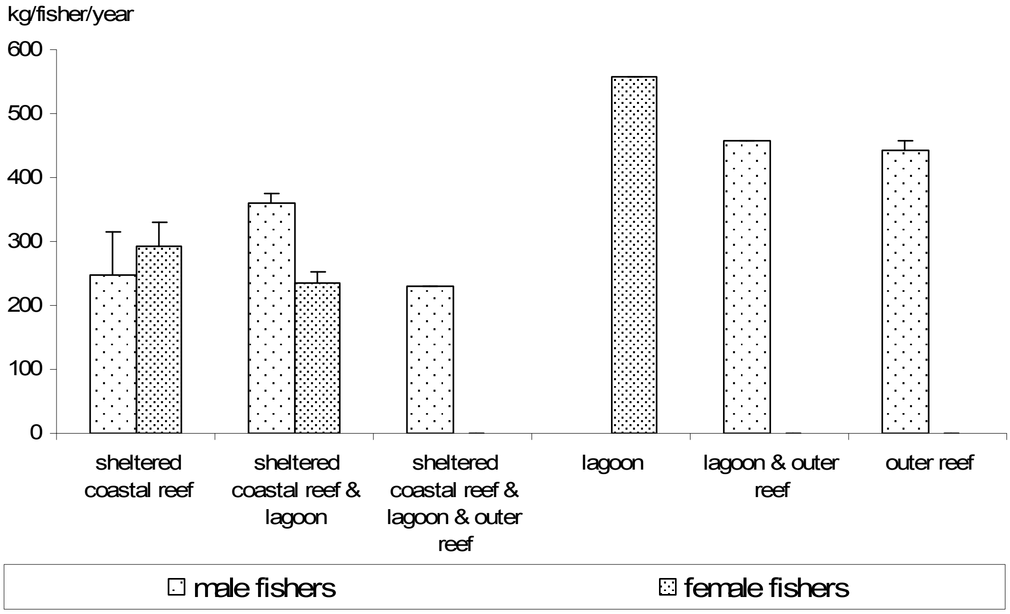

Figure 4.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Rarumana (based on reported catch only).

Comparing productivity rates (CPUE) between genders and among habitats (Figure 4.11) shows that female fishers' efficiency is below that of males. Also, the CPUEs calculated for fishers targeting the lagoon and outer reef seem to be at least as high, if not higher, than CPUEs reported from other habitats. However, overall, CPUEs are low, ~1–1.25 kg per hour of fishing trip for the habitats closer to shore, and 1.2–1.4 kg per hour of fishing trip if the outer reef is fished. This may be a result of the use of non-motorised canoes and low-cost fishing gear, which are less efficient, coupled with the major objective to satisfy subsistence needs rather than commercial interests. The low CPUEs may also suggest a low resource status.

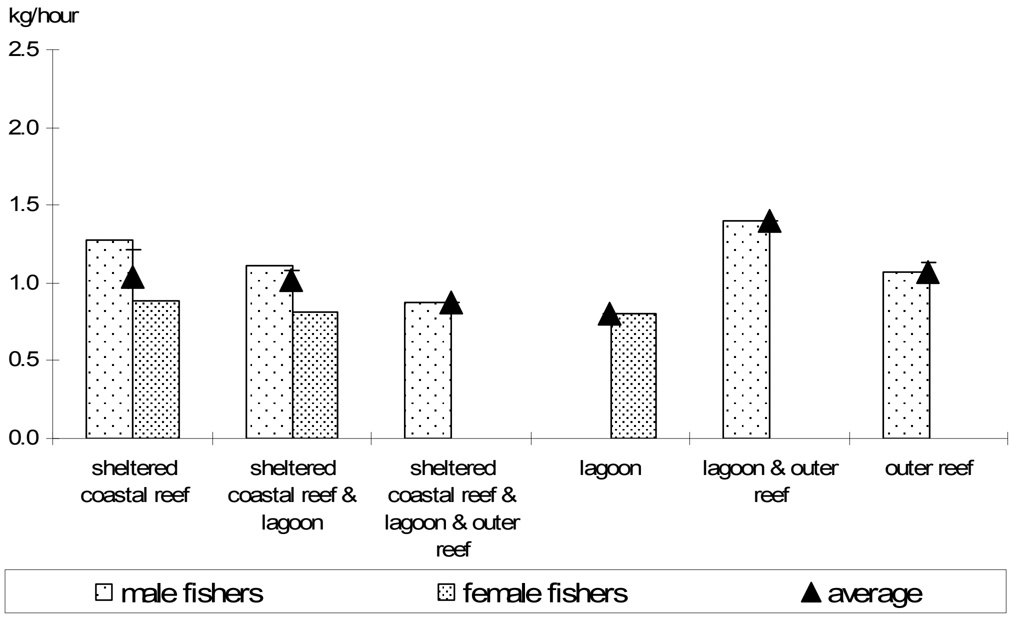

Figure 4.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Rarumana.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The fact that subsistence fishing is more important than commercial fishing for Rarumana's people clearly shows in Figure 4.12. Fishing trips targeting the sheltered coastal reef and in combination with lagoon areas are mostly for subsistence purposes. However, as observed elsewhere, male fishers targeting the outer reef, or the outer reef and lagoon, fish as much for income as for subsistence. Social interests seem not to be a priority, as the non-commercial distribution of catch is a part of the local lifestyle, and also because selling catches and processed fish within the community is one of the limited marketing options.

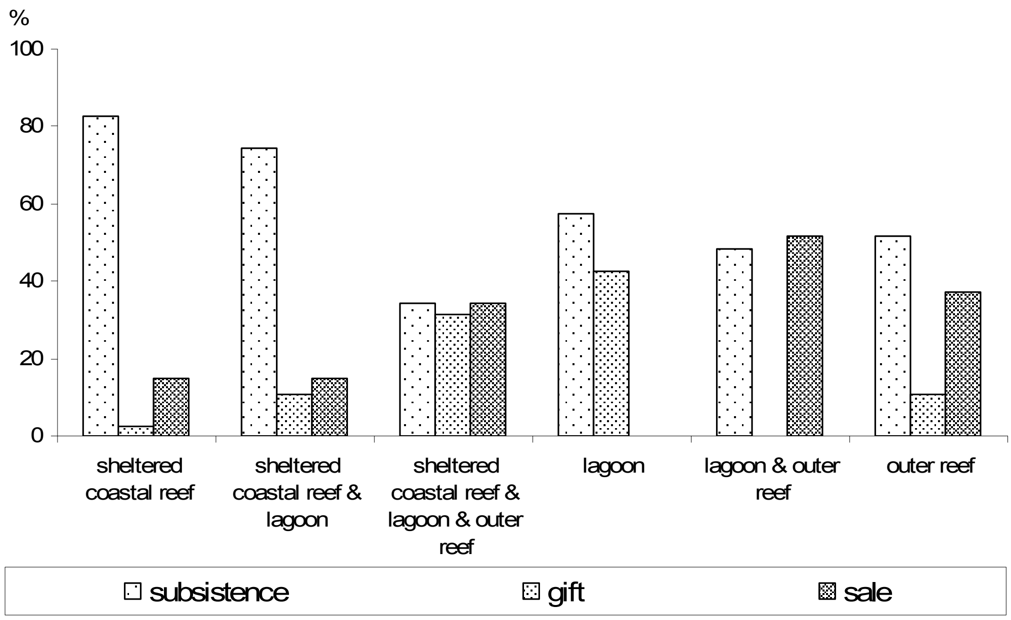

Figure 4.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Rarumana.
Proportions are expressed in % of the total number of trips per habitat.

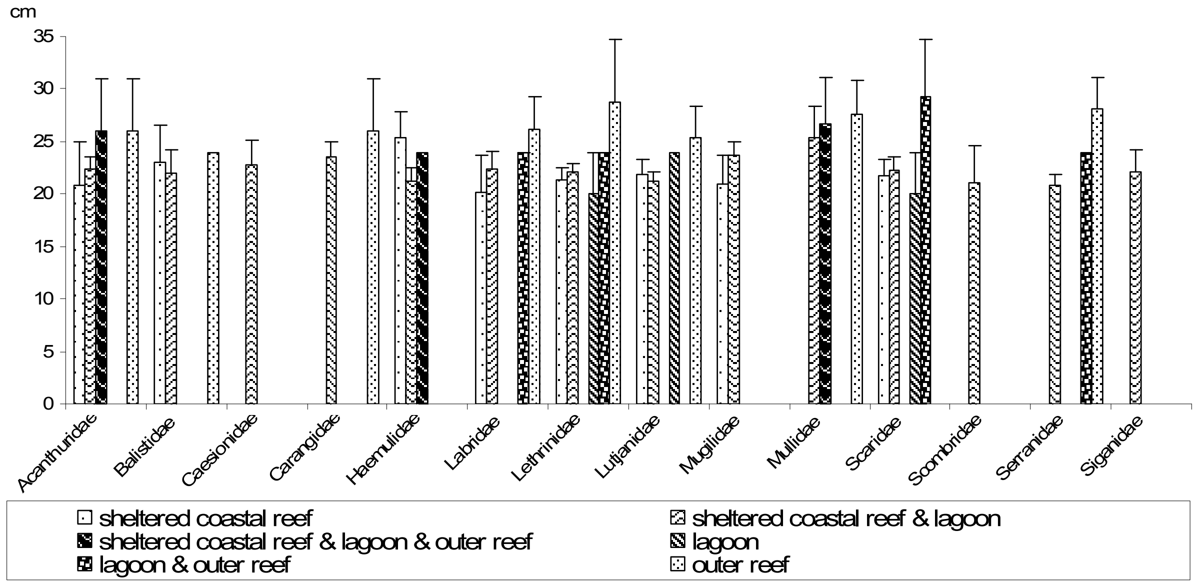

Figure 4.13: Average sizes (cm fork length) of fish caught by family and habitat in Rarumana. Bars represent standard error (+SE).

Comparison of the reported average fish sizes across all habitats (Figure 4.13) and major families shows the expected increase in average fish size with distance from shore. This applies to all major reef and lagoon fish families. In the case of Scaridae, there is a marked difference between the relatively small average fish length if caught in the sheltered coastal reef and lagoon compared to the much larger average fish length at the outer reef. The use of spear diving close to shore may have contributed to this effect. Generally speaking, reported average fish lengths are >20 cm and ~25 cm and larger if the outer reef is targeted.

The selection of indicators to assess current fishing pressure on Rarumana's reef and lagoon resources is shown in Table 4.4. Most fishers target either the sheltered coastal reef alone, or in combination with the lagoon. Calculations show that there are high fisher densities in the coastal and outer reef areas, while fisher density in the lagoon alone seems to be negligible. However, if we combine the surface areas of the sheltered coastal reef and lagoon (66.78 km²) and the numbers of fishers who exclusively target the sheltered coastal reef and lagoon and those who combine both habitats (788 fishers), we reach a density of 12 fishers/km², indicating moderate fishing pressure. Overall, fisher and population densities of the community's total reef and total fishing ground areas are moderate-to-high (35 fishers and 72 people/km²) for the total reef area, and low-to-moderate for the total fishing ground area (13 fishers and 26 people/km²). Subsistence catch per reef area is ~4 t/year and for the total fishing ground 1.5 t/year only. These figures do not suggest any cause for alarm, even though they represent only 61% of the total annual catch, i.e. total fishing pressure is 39% higher. However, taking into account the reported frequent poaching by external fishers entering Rarumana's fishing ground to catch for the Gizo market, the impact imposed by the Rarumana community's fishing may well underestimate the actual fishing pressure.

Table 4.4: Parameters used in assessing fishing pressure on finfish resources in Rarumana

Parameters	Habitat							
	Sheltered coastal reef	Sheltered coastal reef & lagoon	Sheltered coastal reef & lagoon & outer reef	Lagoon	Lagoon & outer reef	Outer reef	Total reef	Total fishing ground
Fishing ground area (km^2)	3.21	n/a	n/a	63.57	n/a	1.93	24.94	68.71
Density of fishers (number of fishers/km^2 fishing ground) (1)	49	n/a	n/a	0.3	n/a	32	35	13
Population density (people/km^2) (2)							72.3	26.2
Average annual finfish catch (kg/fisher/year) (3)	274.41 (±33.57)	323.14 (±15.15)	228.78 (n/a)	558.32 (n/a)	456.65 (n/a)	442.34 (±15.59)		
Total fishing pressure of subsistence catches (t/km^2)							4.2	1.5
Total number of fishers	156	614	12	18	12	62	874	874

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1803; total number of fishers = 874; total subsistence demand = 104.5 t/year; (3) catch figures are based on recorded data from survey respondents only.

4.2.4 Catch composition and volume – invertebrates: Rarumana

Calculating catches reported from invertebrate fishers by wet weight shows that a number of species are heavily exploited. Most reported annual catch by wet weight is accounted for by giant clams; *Hippopus hippopus*, *Tridacna crocea* and *T.* spp. are exploited at about 6 t/year (wet weight). *Strombus* sp. and *Charonia tritonis* each determine another 4–5 t/year (wet weight) followed by five other species (mud crab, *Anadara* sp., trochus, *Modiolus auriculatus*) that each account for ~2 t/year (wet weight). *Holothuria* spp. and lobsters, as well as others, are less important (~200–1300 kg/year, wet weight) (Figure 4.14).

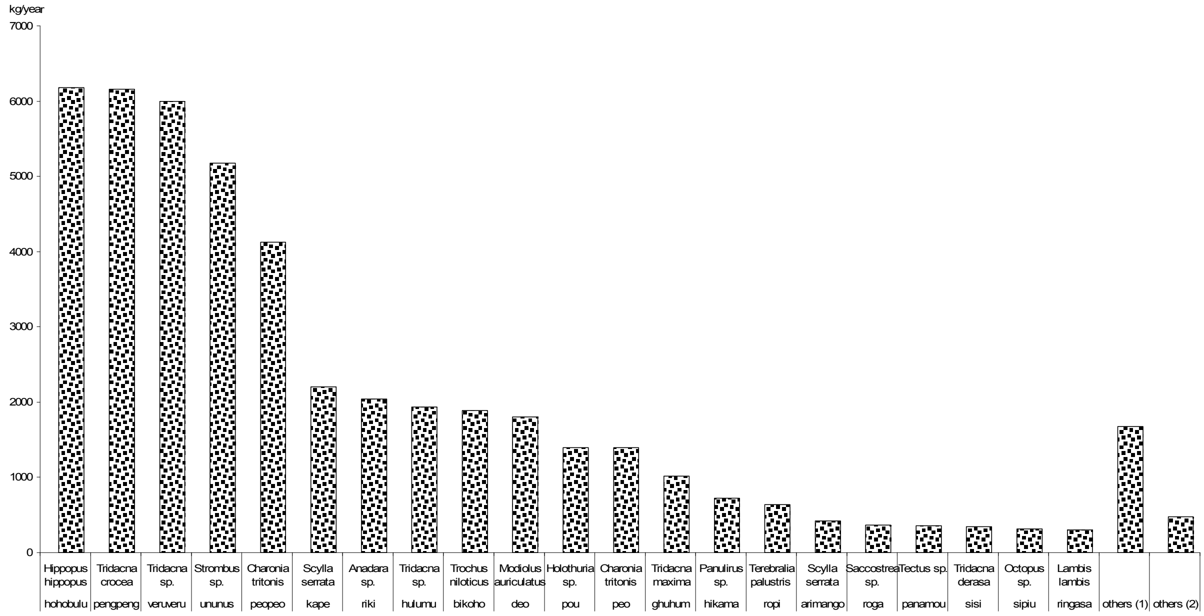

Figure 4.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Rarumana.
'Others (1)' include: *Cardisoma* sp. (*gharumu*, *kakautia*), *Nerita polita* (*sise*), *Turbo* sp. (*poputo*), *Tripneustes* sp. (*tawaii*), *Scylla serrata* (*kapehe*), *Asaphis violascens* (*inunus*), *Trochus niloticus* (*lala*) (all <300–>100 kg/year); 'others (2)' include: *Anadara* sp. (*keke*), *Lambis* sp. (*nawa*), *Tripneustes gratilla* (*tavai*), *Thais* sp. (*paupasua*), *Turbo* sp. (*rariri*), *Telscopium telescopium* (*ropiatu*, *u*), *Donax cuneatus* (*oreore*, *huhute*), *Anadara* sp. (*aau*), *Periglypta reticulata* (*kauia*), *Pitar prora* (*manuri*), *Turbo* sp. (*ariri*), *ime* (all <100 kg/year).

The fact that Rarumana fishers target a wide range of species across many habitats also shows in the number of vernacular names registered by respondents. Reeftop gleaning and diving for mostly reef-associated species is described by the highest number of vernacular names (28), and mangrove and soft benthos fishing is represented by 13 vernacular names. Others, either focusing on one habitat or a particular commercial fisheries, are less diverse and are described by a few reported vernacular names only (Figure 4.15).

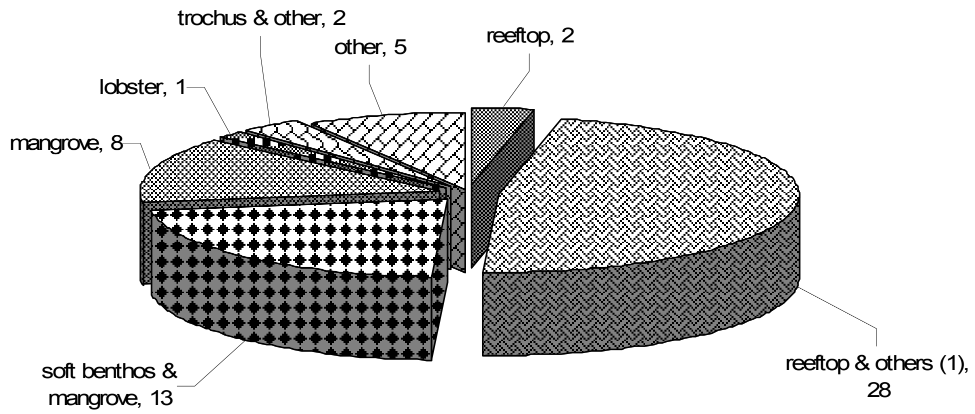

Figure 4.15: Number of vernacular names recorded for each invertebrate fishery in Rarumana.
'Others (1)': other, trochus, intertidal and soft benthos.

The average annual catch per fisher by gender and fishery (Figure 4.16) reveals substantial differences among fisheries. Most fisheries provide catches of <100–600 kg/fisher/year. However, the combined fishing of reeftop, trochus and other, intertidal and reeftop and other, and soft benthos and intertidal and reeftop and other, render average annual catches as high as 1.1–1.4 t/fisher/year. Taking into account the earlier observation that giant clams determine most of the total annual catch by wet weight, it is not surprising that fishers who target reeftop habitats for gleaning and diving, thus targeting giant clams, are those who have the highest catch rates. In contrast, commercial species, such as lobsters or trochus and 'other' show very low average annual catch rates. Considering that there are little opportunities for Rarumana fishers to generate income, these low catch rates suggest that the resource status is low. Certainly, if specialised commercial fisheries were in good shape, fishers would focus much more on these to increase their income.

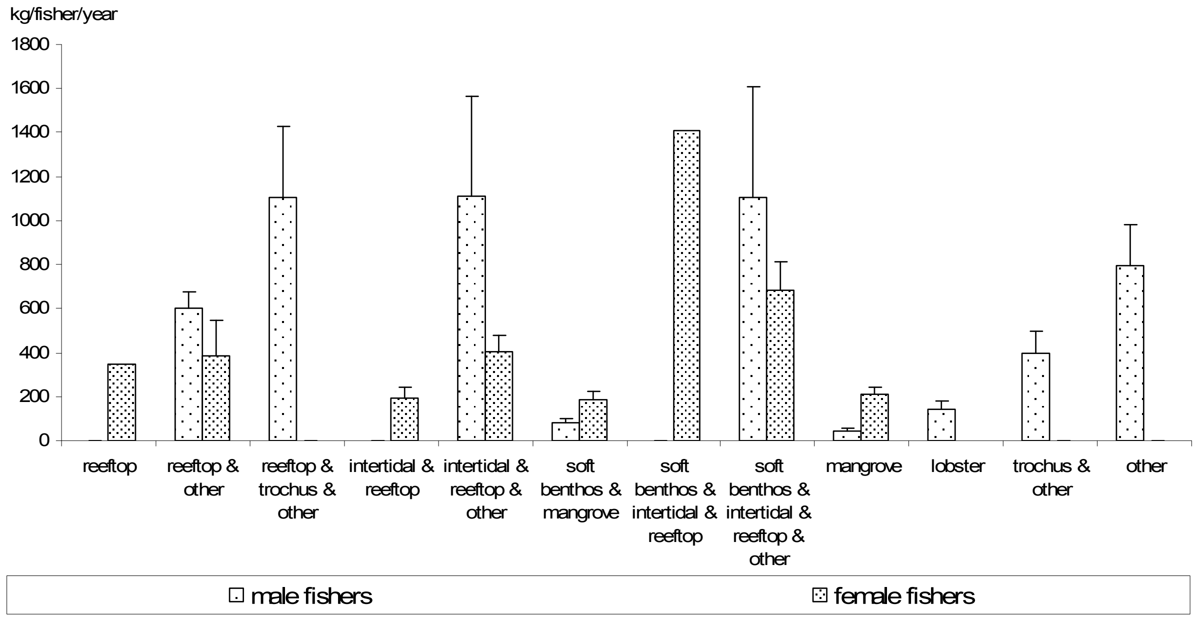

Figure 4.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Rarumana.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 34 for males, n = 36 for females).

The above observation that invertebrate collection mainly serves subsistence needs, and only to a marginal extent income generation in Rarumana, is confirmed by results shown in Figure 4.17. The proportion that is sold on the local or any other market may not exceed 0.6% of the total annual reported catch or 312 kg/year if assuming that half of the share that may be consumed or sold is indeed sold. There is no record for a species or a catch that is exclusively collected for sale. This also applies to trochus, as the meat is locally consumed although the shells may be sold.

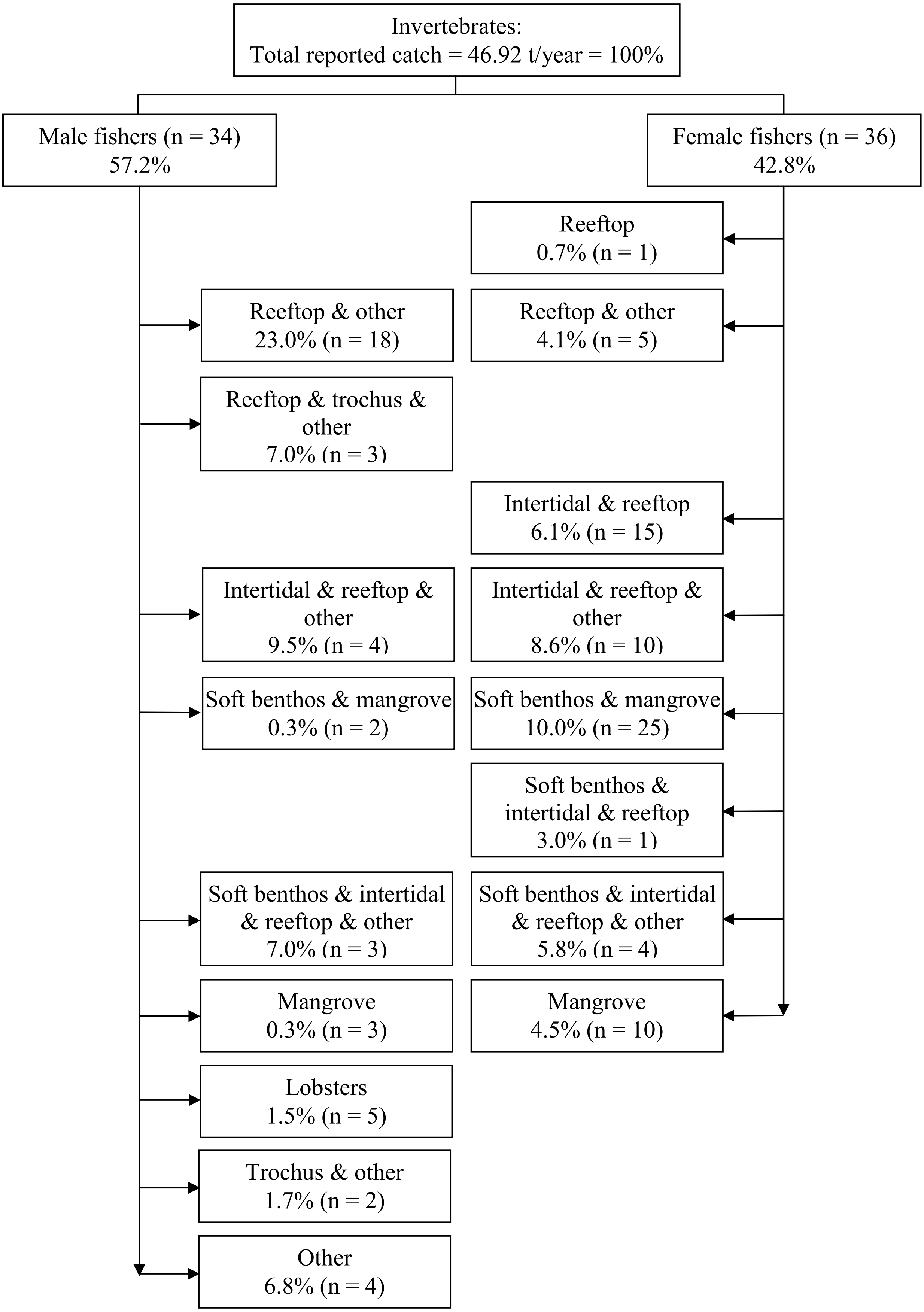

Figure 4.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Rarumana.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

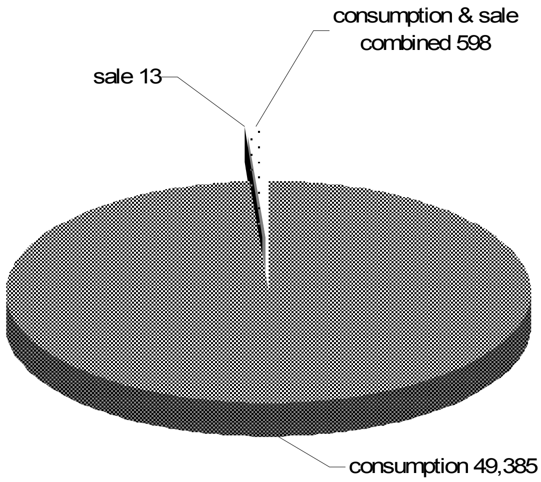

Figure 4.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Rarumana.

As mentioned earlier, male fishers in Rarumana are engaged in invertebrate fishing as much as female fishers. Males account for 57% of the total annual catch, and females 43% (Figure 4.18). Most of Rarumana's male invertebrate fishers glean the reeftops for giant clams, and also dive ('other'), and this makes up the highest proportion of the total annual catch (wet weight), i.e. ~37%. Female fishers add another ~5% of total annual catch to reeftop resources. As shown by average annual catches and numbers of fishers, soft benthos and mangroves resources are subject to the second-most annual impact by wet weight (>15% of total annual catch). The impact on lobsters, if targeted as a specialised fishery, is negligible (1.5% of the total annual catch). Overall, the fact that invertebrates are harvested mostly for subsistence purposes, coupled with the wide range of habitats available, shows in the fact that annual impact is scattered over all habitats, and no habitats are targeted separately, rather combined during each fishing trip.

Table 4.5: Parameters used in assessing fishing pressure on invertebrate resources in Rarumana

Parameters	Fishery / Habitat					
	Reeftop	Reeftop & other (4)	Reeftop & trochus & other (4)	Intertidal & reeftop	Intertidal & reeftop & other	Soft benthos & mangrove
Fishing ground area (km^2)	8.29	14.07	14.07			
Number of fishers (per fishery) (1)	10	254	34	154	147	279
Density of fishers (number of fishers/km^2 fishing ground)	1	18	2			
Average annual invertebrate catch (kg/fisher/year) (2)	345.26 (n/a)	553.56 (±69.87)	1102.29 (±326.69)	189.48 (±51.64)	604.93 (±155.88)	1407.09 (n/a)

Parameters	Fishery / Habitat					
	Soft benthos & intertidal & reeftop	Soft benthos & intertidal & reeftop & other	Mangrove	Trochus & other	Lobster (3)	Other
Fishing ground area (km^2)				5.78	24.72	5.78
Number of fishers (per fishery) (1)	10	75	136	22	56	45
Density of fishers (number of fishers/km^2 fishing ground)				4	2	8
Average annual invertebrate catch (kg/fisher/year) (2)	1407.09 (n/a)	862.32 (±219.63)	171.20 (±33.59)	397.37 (±102.06)	144.06 (±34.25)	792.57 (±189.82)

Figures in brackets denote standard error; n/a = no information available; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) outer-reef linear measurement (km); (4) combined shallow inside lagoon and outer-reef areas.

Taking into account figures available on the surface areas of fishing habitats, none of the fisheries is subjected to high fisher density. A large number of fishers target the reeftop by gleaning and diving; however, due to the available reef surface, a density of ~21 fishers/km² results if adding up all fishers targeting the reeftop, reeftop and 'others', and reeftop and trochus and 'others' fisheries. Although the surface areas for mangroves and soft benthos are not known, the total number of fishers does not suggest a high fisher density. However, if taking into account the high average annual catches (wet weight) for fishers targeting reef and associated habitats, as well as for soft benthos and associated habitats, fishing impact may be high, particularly on target species such as giant clams (Table 4.5). However, before final assessment is made, results need to be compared and considered together with results from the resource surveys.

4.2.5 Management issues: Rarumana

As mentioned at the beginning of this report, there is normally a division between governmental legal and traditional village systems for the management of marine resources in Solomon Islands. However, in the case of Rarumana, no fisheries management interventions were found to be in place. There were also no traditional regulations on the use of fisheries resources. On the other hand, people expressed concern about the observed decreases in fish sizes, longer time needed to catch the same amount of fish that they previously caught in a shorter time, and also poaching by external fishers who serve the Gizo market.

The presence of crocodiles, especially in mangroves and muddy water zones, helps to limit fishing in the affected areas, as well as limiting fishing at night. Also, limited marketing options help keep the fishing level for sales outside the community and Rarumana Island low.

However, the concerns expressed on the perceived decline in marine resources, and the possible detrimental impact by external commercial fishers demands fisheries management interventions. The exploitation level to satisfy the island's own subsistence needs is high and likely to remain at that level. Thus, using a community management approach, interventions including regulating fishing pressure on certain areas, designating protected zones, ensuring compliance with the temporary bans on target species and respect for size limits are urgently needed. Other income possibilities, particularly focusing on agricultural produce, may help to ascertain people's livelihoods and contribute to lowering fishing pressure due to income needs.

4.2.6 Discussion and conclusions: socioeconomics in Rarumana

The Rarumana community is a rural coastal island community in Western Province with little access to market opportunities for selling their fishery produce. Market access is limited by the oversaturated market at Gizo, little local market capacity and transport costs to the Honiara market. Lack of electricity and thus easy access to ice making also makes it difficult to transport fresh fishery produce, or to process fishery produce on a large scale. Income possibilities from fishing are further reduced by the temporary governmental ban on bêche-de-mer harvesting and the current ban on the aquarium trade fishery due to an ongoing court case. The community's lifestyle is determined by agricultural production, also the most important means of generating cash income. The purchasing power of the people for imported food and other items is low. In addition to fisheries, local business activities, including food preparation and food, lime and betel nut sales, provide other income opportunities.

At the time of the survey, no governmental, NGO or traditional fisheries management interventions were in place. People, however, complained about decreasing fish sizes, and the poaching by commercial fishers from outside the area to supply the Gizo market. While fisher and population densities are not alarmingly high, additional external fishing pressure (poaching) may have detrimental effects on the community's reef and lagoon resources.

In summary, survey results suggest the following:

- Rarumana's population has an important dependence on their marine resources for home consumption and, to a lesser extent, for income generation. Fresh fish consumption (~111 kg/person/year) is high and represents the most important food and protein source.

- Tradition does not demand particular gender roles, but labour is shared. Females are the only exclusive invertebrate fishers, while exclusive finfish fishers are mostly males. However, most fishers, male and females, fish for both finfish and invertebrates

- Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes. The important amount taken from the outer reef is mainly caught by male fishers and some of this catch is intended for commercial purposes.

- Overall, CPUEs are low, ~1–1.25 or 1.2–1.4 kg catch of finfish per hour of fishing trip, depending whether nearshore or outer-reef habitats are targeted. These low CPUEs are due to inefficient fishing techniques, low-cost fishing gear, the fact that fishing is done for food rather than sale, and/or low resource status.

- A wide range of traditional and mostly low-cost fishing techniques is used, often in combination. Handlines and spear diving are the main methods used in almost all the habitats, while deep-bottom lines and trolling are also used at the outer reef. The average reported fish size is about 25 cm, with some fish reaching >25 cm in catches reported from the outer reef. Most families show the expected increase in average fish size with distance from shore.

- Results from the invertebrate fisher survey show that catches of giant clams, in particular *Hippopus hippopus* and *Tridacna crocea*, but also other Tridacnidae, *Strombus* sp., and *Charonia tritonis*, account for most of the annual harvest (wet weight). Most invertebrate catch is used for home consumption only.

- In contrast to finfish fishing, significant differences were found in the average annual catches by invertebrate fishery. Annual average catches reported for the combined gleaning of reeftops and diving for giant clams, the combination of intertidal, reeftop and 'other' (giant clams), and soft benthos, intertidal, reeftop and 'other' (giant clam) are by far the highest, while catches from all other fisheries are rather small.

- Fishing pressure indicators calculated for finfish fisheries suggest that, due to the available reef and overall fishing ground area, fisher and population densities and subsistence catch per available surface unit area are moderate or low. Overall, the current exploitation level of invertebrates for subsistence and commercial use is not alarmingly high. However, fisher density is high for reeftop gleaning and diving for giant clams. The reported average annual catches of trochus are low and not many fishers are engaged in this commercial fishery, which suggests that resource status is low. This may also apply to giant clams, one of the most sought-after species groups.

4.3 Finfish resource surveys: Rarumana

Finfish resources and associated habitats were assessed between 8 and 14 August 2006 from a total of 24 transects (6 sheltered coastal, 6 intermediate, 6 back- and 6 outer-reef transects; see Figure 4.19 and Appendix 3.3.1 for transect locations and coordinates respectively).

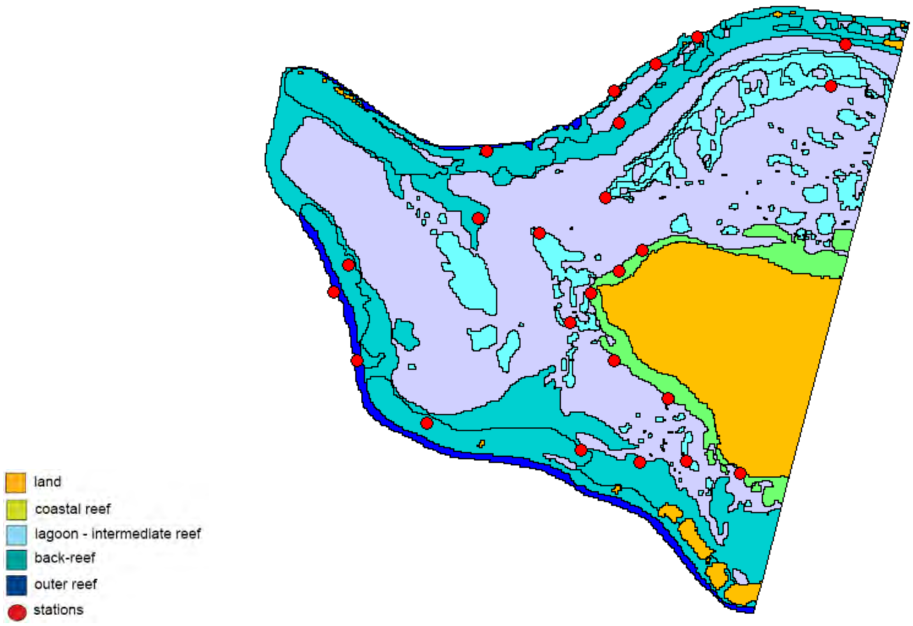

Figure 4.19: Habitat types and transect locations for finfish assessment in Rarumana.

4.3.1 Finfish assessment results: Rarumana

A total of 21 families, 61 genera, 211 species and 7443 fish were recorded in the 24 transects (See Appendix 3.3.2 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 48 genera, 182 species and 6003 individuals.

Finfish resources varied slightly among the four reef environments found in Rarumana (Table 4.6). The outer reef contained the highest density (0.6 fish/m^2), biomass (140 g/m^2), and biodiversity (65 species/transect) of all four habitats. In contrast, the coastal reefs displayed the lowest of all biological parameters: density (0.4 fish/m^2), size (17 cm), size ratio (55%), biomass (65 g/m^2) and biodiversity (45 species/transect). Intermediate lagoon reefs displayed the highest values of average fish size and the second-highest biomass, while back-reefs displayed the highest size ratio.

Table 4.6: Primary finfish habitat and resource parameters recorded in Rarumana (average values ±SE)

Parameters	Habitat				
	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	3.2	7.6	19.8	1.9	32.5
Depth (m)	4 (1–8) (3)	7 (2–12) (3)	5 (1–15) (3)	7 (1–16) (3)	6 (1–16) (3)
Soft bottom (% cover)	14.7 ±3.0	19.4 ±4.4	8.7 ±3.0	1.6 ±0.6	11
Rubble & boulders (% cover)	7.8 ±3.6	10.5 ±6.6	6.7 ±2.7	2.0 ±1.1	7
Hard bottom (% cover)	50.4 ±5.0	54.6 ±4.8	63.0 ±6.3	69.5 ±3.6	60
Live coral (% cover)	26.7 ±4.3	14.6 ±3.2	21.6 ±3.4	26.3 ±3.7	21
Soft coral (% cover)	0.4 ±0.2	0.7 ±0.3	0.0 ±0.0	0.3 ±0.2	0.2
Biodiversity (species/transect)	45 ±2	48 ±7	47 ±7	65 ±5	51 ±3
Density (fish/m^2)	0.4 ±0.1	0.4 ±0.1	0.4 ±0.1	0.6 ±0.1	0.4
Size (cm FL) (4)	17 ±1	20 ±1	18 ±1	19 ±1	18
Size ratio (%)	55 ±2	55 ±2	61 ±2	59 ±2	59
Biomass (g/m^2)	64.5 ±13.4	90.6 ±25.7	77.1 ±22.7	140.1 ±25.8	82.7

(1) Unweighted average; (2) weighted average that takes into account relative proportion of habitat in the study area; (3) depth range; (4) FL = fork length.

Sheltered coastal reef environment: Rarumana

The sheltered coastal reef environment of Rarumana was dominated by herbivorous Acanthuridae but also by Scaridae and Siganidae (Siganidae in terms of biomass only) and carnivorous Chaetodontidae, Holocentridae (these two only in terms of density) and Nemipteridae (Figure 4.20). The five families excluding Chaetodontidae (20 species) were represented by 47 species; highest abundance and biomass were recorded for *Neoniphon sammara*, *Scolopsis margaritifera*, *Ctenochaetus striatus*, *Acanthurus mata*, *Scarus dimidiatus*, *Scarus globiceps*, *Scolopsis trilineata* and *Siganus lineatus* (Table 4.7). This reef environment was mostly covered by hard bottom (50%), with a high cover of live coral (27%), and good percentage of soft substrate (15%). Such diverse habitat was reflected in the diversity of the fish community composition (Table 4.7 and Figure 4.20).

Table 4.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Rarumana

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.020 ±0.004	1.4 ±0.3
	Acanthurus mata	Elongate surgeonfish	0.016 ±0.016	6.3 ±6.3
Holocentridae	*Neoniphon sammara*	Blood-spot squirrelfish	0.039 ±0.018	3.0 ±1.5
Nemipteridae	*Scolopsis margaritifera*	Pearly monocle bream	0.031 ±0.011	6.2 ±2.6
	Scolopsis trilineata	Three-lined monocle bream	0.008 ±0.003	1.0 ±0.3
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	0.011 ±0.003	1.1 ±0.2
	Scarus globiceps	Globehead parrotfish	0.008 ±0.004	1.2 ±0.6
Siganidae	*Siganus lineatus*	Goldenlined rabbitfish	0.007 ±0.005	7.0 ±5.5

The density of fish in the coastal reefs in Rarumana was the second-highest at the site, lower only than in the outer reefs. However, size, size ratio, biomass, and biodiversity were the lowest recorded at the site. When compared to the other coastal habitats studied in the country, Rarumana values were intermediate between Marau and Chubikopi, with a biomass almost four times lower than that in Marau's coastal reefs. Carnivorous fish dominated the trophic structure in terms of both density and biomass. Other than Holocentridae and Nemipteridae, Lethrinidae, Lutjanidae and Mullidae were an important component of the carnivore community. Mullidae, Lethrinidae, Labridae, Serranidae and Acanthuridae showed very low values of size ratio, probably suggesting an impact from fishing. The substrate offered different types of habitat for the several components of the fish community, where herbivores are associated with hard bottom (50% of total substrate surface) and certain carnivore species are associated with soft bottom (15%); the high abundance of Chaetodontidae reflected the high live-coral cover (27%).

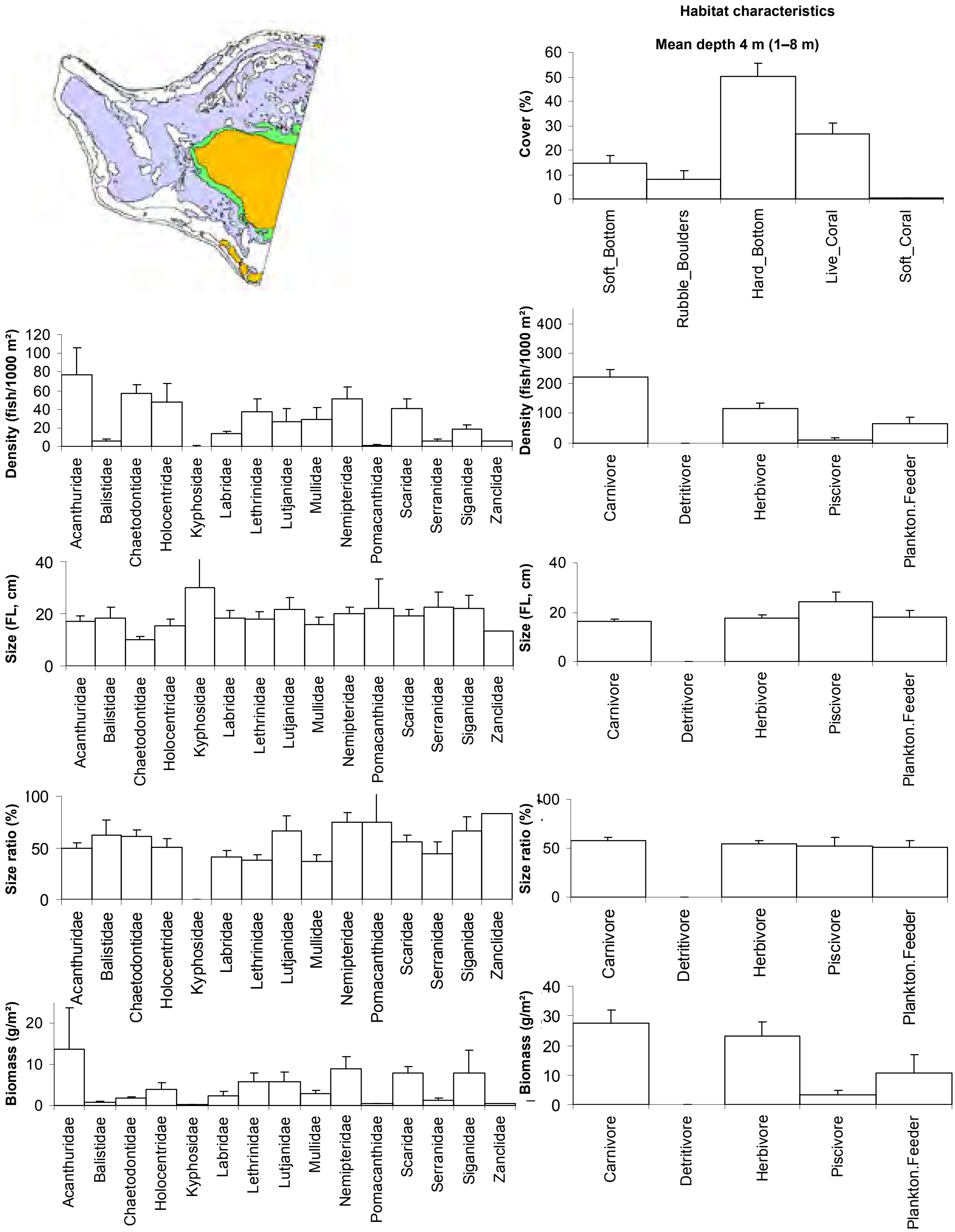

Figure 4.20: Profile of finfish resources in the sheltered coastal reef environment of Rarumana. Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Rarumana

The intermediate reef environment of Rarumana was dominated by herbivorous Acanthuridae and Scaridae and by carnivorous Chaetodontidae (23 species), Lutjanidae and Lethrinidae (Figure 4.21). These families were represented by 48 species. Highest abundance and biomass were recorded for *Lutjanus gibbus*, *Monotaxis grandoculis*, *Ctenochaetus striatus*, *Acanthurus blochii*, *A. pyroferus*, *Scarus dimidiatus*, *Chlorurus sordidus* and *Scarus ghobban* (Table 4.8). This reef environment presented a clear dominance of hard bottom (55%), a low cover of live coral (15%), and a good cover of soft bottom (20%).

Table 4.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Rarumana

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.032 ±0.014	2.7 ±1.4
	Acanthurus blochii	Ringtail surgeonfish	0.013 ±0.004	6.1 ±1.9
	Acanthurus pyroferus	Chocolate surgeonfish	0.011 ±0.008	1.4 ±1.2
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	0.011 ±0.006	2.0 ±1.1
	Chlorurus sordidus	Daisy parrotfish	0.010 ±0.008	2.6 ±1.9
	Scarus ghobban	Bluebarred parrotfish	0.008 ±0.005	5.0 ±3.3
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.034 ±0.016	9.6 ±4.8
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.034 ±0.030	11.3 ±9.7

Fish biodiversity in the intermediate reef of Rarumana was the second-highest at the site (48 species/transect), while fish density was the lowest of the four habitats. While average fish size was the largest (19 cm FL), size ratio was comparable to the lowest value, recorded at the coastal habitat. On the other hand, biomass was the second-highest after outer reefs. Compared to the other sites in the country, Rarumana intermediate reefs displayed the second-highest level of biodiversity, density and biomass, which were lower only than in Marau. However, size ratio was much higher than both the Marau and Chubikopi values. Carnivorous fish were more abundant than herbivorous fish; however, biomass was only slightly dominated by herbivores. Lethrinidae, Mullidae, Holocentridae, Serranidae and Lutjanidae displayed low size ratios, lower than 50% of maximum size. This information usually suggests a negative response of the fish population to fishing. The substrate was dominated by hard bottom, usually advantaging herbivores such as Acanthuridae; however, soft bottom was also well represented, probably explaining the high abundance of some Lethrinidae.

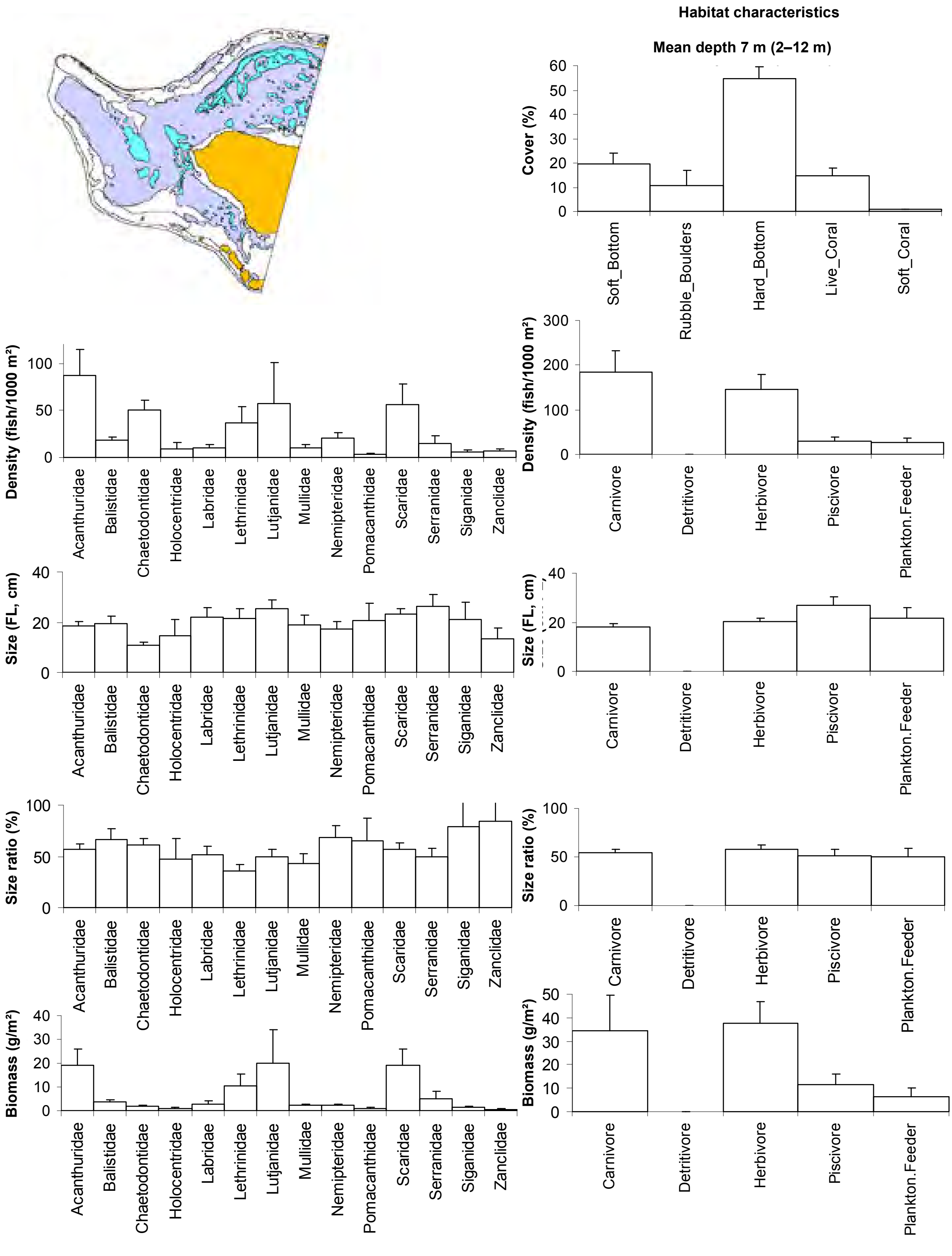

Figure 4.21: Profile of finfish resources in the intermediate-reef environment of Rarumana.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Rarumana

The back-reef environment of Rarumana was dominated by herbivorous Acanthuridae and Scaridae and, to a lesser extent and only for density, Chaetodontidae (17 species). Scaridae was the most important family in terms of biomass (Figure 4.22). These three families were represented by 27 species; particularly high abundance and biomass were recorded for *Scarus psittacus*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *S. dimidiatus*, *S. oviceps*, *Acanthurus blochii* and *Chlorurus bleekeri* (Table 4.9). This reef environment presented only a moderately diverse habitat with a dominance of hard bottom (63%) and relatively good proportion of live coral (22%), therefore not favouring a rich composition.

Table 4.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Rarumana

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.032 ±0.011	2.4 ±1.0
	Acanthurus blochii	Ringtail surgeonfish	0.009 ±0.004	5.1 ±3.2
Scaridae	*Scarus psittacus*	Common parrotfish	0.036 ±0.024	8.0 ±6.4
	Chlorurus sordidus	Daisy parrotfish	0.021 ±0.012	5.8 ±4.3
	Scarus dimidiatus	Yellow-barred parrotfish	0.015 ±0.008	4.0 ±2.6
	Scarus oviceps	Dark-capped parrotfish	0.012 ±0.008	5.6 ±4.0
	Chlorurus bleekeri	Bleeker's parrotfish	0.008 ±0.006	4.4 ±3.0

The density, average size, biomass and biodiversity of fish in the back-reefs of Rarumana displayed the second-lowest values of the site, higher only than in coastal reefs. However, size ratio was the highest (61%). When compared to the other two back-reefs studied in the country, Rarumana displayed intermediate values between Marau and Chubikopi. Herbivorous fish dominated the trophic structure of the fish community in this habitat, both in terms of density and biomass. Carnivores were almost absent. Lethrinidae, Mullidae and, to a lower extent, Holocentridae and Serranidae displayed very low size ratios, much below 50%, suggesting heavy impact from fishing.

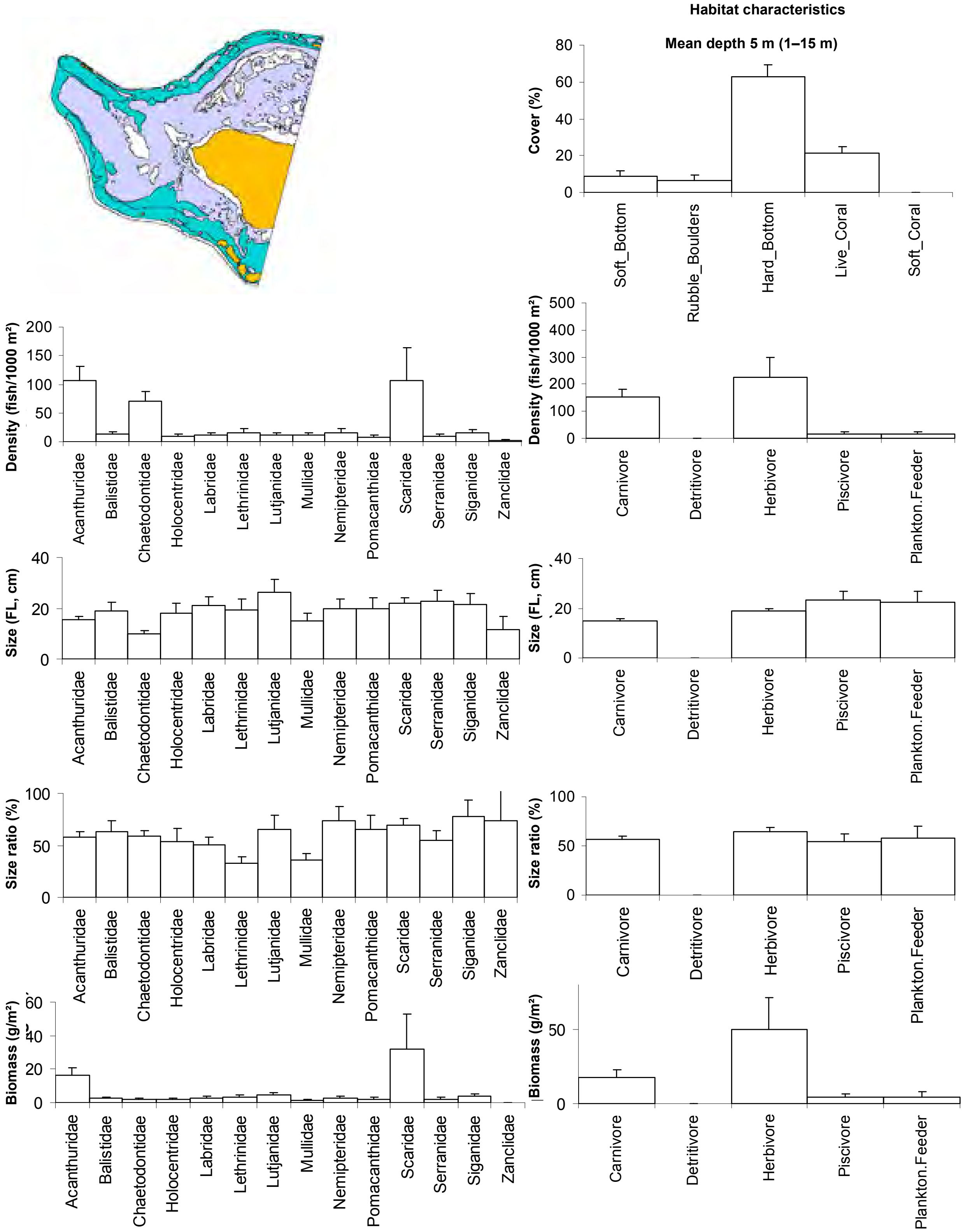

Figure 4.22: Profile of finfish resources in the back-reef environment of Rarumana.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Rarumana

The outer-reef environment of Rarumana was dominated by two families of herbivorous fish: Acanthuridae and Scaridae and, to a much lower extent, by Chaetodontidae (only for density, with 25 species, Figure 4.23). The two major families were represented by 38 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Acanthurus blochii*, *Chlorurus sordidus*, *A. lineatus*, *Scarus psittacus* and *S. niger* (Table 4.10). This reef environment presented a very high dominance of hard bottom (69%) and a high coral cover, more than 25% (Table 4.6 and Figure 4.23). The almost total lack of soft bottom (2% cover) could explain the absence of families associated with sand.

Table 4.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Rarumana

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.105 ±0.045	8.3 ±3.6
	Acanthurus blochii	Ringtail surgeonfish	0.047 ±0.037	32.9 ±27.1
	Acanthurus lineatus	Lined surgeonfish	0.020 ±0.009	4.7 ±2.3
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.033 ±0.020	7.5 ±4.7
	Scarus psittacus	Common parrotfish	0.018 ±0.010	4.7 ±2.6
	Scarus niger	Black parrotfish	0.012 ±0.002	4.9 ±1.1

The biodiversity, density and biomass of finfish in the outer reef of Rarumana were the highest among the habitat. However, average size was lower than in intermediate reefs and size ratio lower than in back-reefs. Compared to the other three country sites, in Rarumana, biodiversity in the outer reefs was still the highest, but density, size ratio and biomass were lower than in both Nggela and Marau, while average size was the lowest overall. The trophic structure in Rarumana outer reefs was strongly dominated by herbivorous fish. Labridae, Lethrinidae and Mullidae had size ratios much below 50%, suggesting a high level of exploitation.

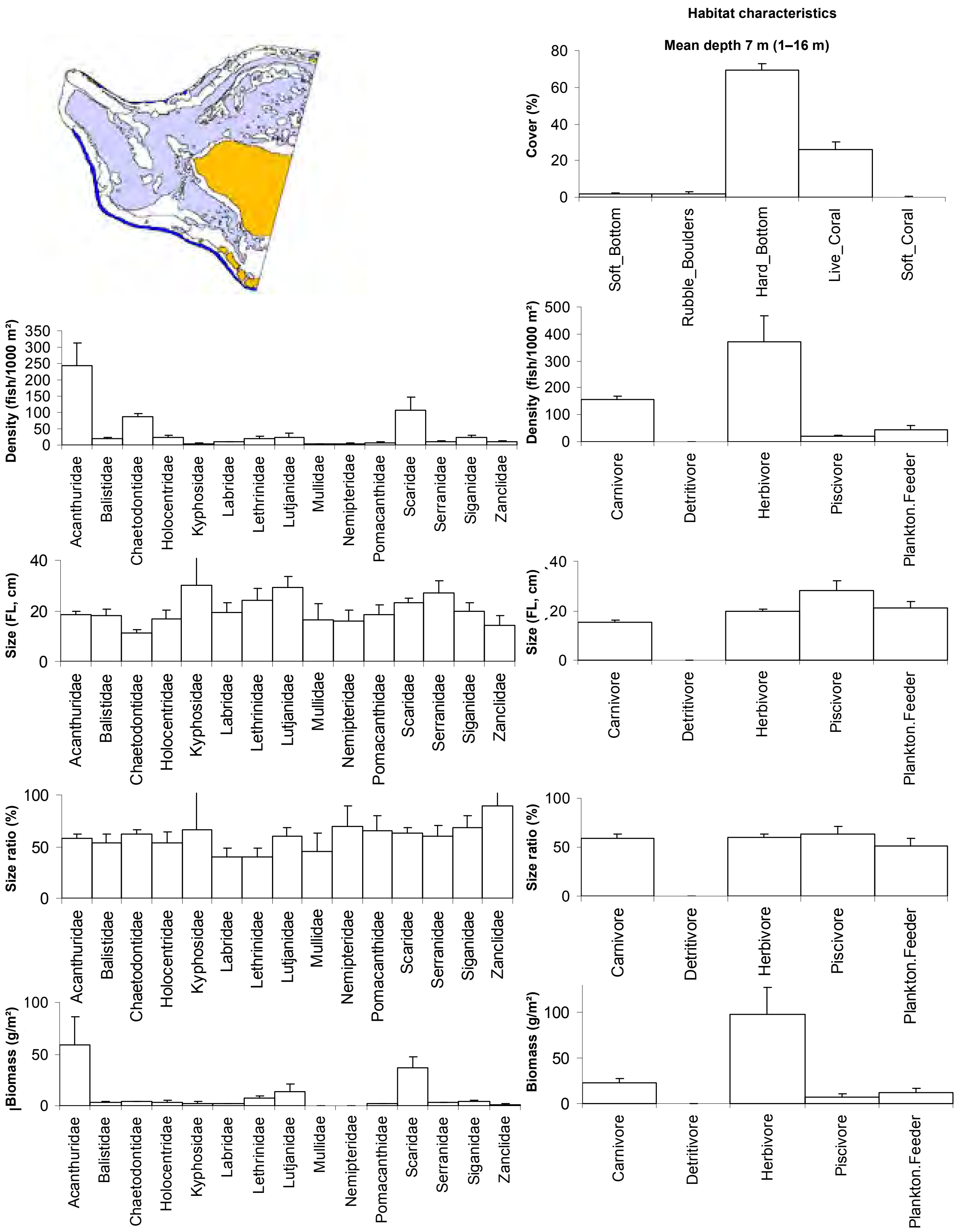

Figure 4.23: Profile of finfish resources in the outer-reef environment of Rarumana.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Rarumana

Overall, the fish assemblage of Rarumana was dominated by Acanthuridae, Scaridae and Chaetodontidae (the latter only in terms of abundance, with 29 species, Figure 4.24). The two major families were represented by a total of 50 species, dominated (in terms of density and biomass) by *Ctenochaetus striatus*, *Scarus psittacus*, *Chlorurus sordidus*, *Acanthurus blochii* and *S. dimidiatus* (Table 4.11). As expected, the overall fish assemblage in Rarumana shared characteristics of back-reef mainly (61% of total reef), then intermediate reefs (23%), and only to a small extent outer reefs (6%) and coastal reefs (1%). The overall habitat was mainly covered by hard bottom (60%), with ~20% of coverage of live coral.

Table 4.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Rarumana (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04	2.7
	Acanthurus blochii	Ringtail surgeonfish	0.01	6.7
Scaridae	*Scarus psittacus*	Common parrotfish	0.02	5.3
	Chlorurus sordidus	Daisy parrotfish	0.02	4.6
	Scarus dimidiatus	Yellow-barred parrotfish	0.01	3.1

Overall, Rarumana appears to support an average-to-low finfish resource, richer than in Chubikopi but much poorer than in Marau, with biomass only one-third as high as in Marau. These results suggest that the finfish resource in Rarumana is in rather poor condition. Moreover, detailed assessment at family level revealed a poor fish community composition, with low diversity of the most important species, and the trophic composition dominated by herbivores, especially in terms of biomass. Carnivore families were very rare. Size ratios were very low for Lethrinidae, Labridae and Mullidae. Both the abundance and the average size of these carnivores indicate a high level of fishing.

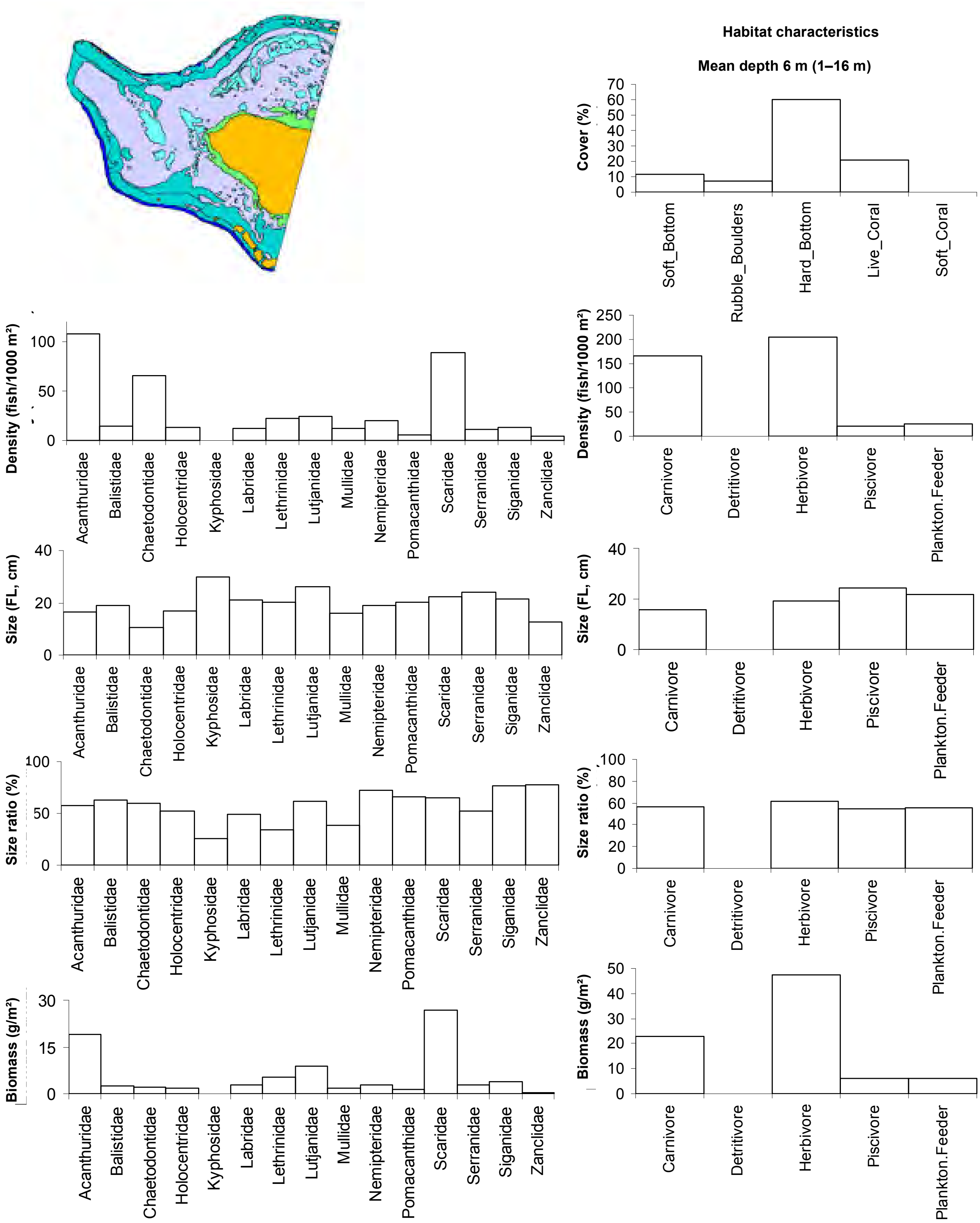

Figure 4.24: Profile of finfish resources in the combined reef habitats of Rarumana (weighted average).
FL = fork length.

4.3.2 Discussion and conclusions: finfish resources in Rarumana

The present assessment indicated that the status of finfish resources in Rarumana is low compared to the average across Solomon Island study sites. Detailed assessment at reef level revealed that density, size and biomass were generally lower than at corresponding reef habitats in Marau but higher than in Chubikopi. Only biodiversity was extremely high in the outer reef, where it reached the top value among all habitats and sites. A consistent dominance of herbivore families, especially Acanthuridae and Scaridae, in the back-reefs and outer reefs, was an indication of a high level of fishing. Carnivores (Lutjanidae and Lethrinidae) were only present in any numbers in back- and outer reefs. Lethrinidae and Mullidae displayed constantly low size ratios, suggesting they are subject to heavy fishing. Lutjanidae and Serranidae displayed a similar trend of reduction in average size in intermediate and coastal reef respectively.

- Overall, Rarumana resources appeared to be in rather poor condition. The reef habitat appeared relatively rich but fish biomass and abundance were much lower compared to the other country sites, except Chubikopi.

- Rarumana populations of snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) were low, and small in average size, indicating an impact from fishing.

4.4 Invertebrate resource surveys: Rarumana

The diversity and abundance of invertebrate species at Rarumana were independently determined using a range of survey techniques (Table 4.12): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 4.25) and finer-scale assessment of specific reef and benthic habitats (Figures 4.26 and 4.27).

The main objective of the broad-scale assessment is to describe the distribution pattern of invertebrates (rareness/commonness, patchiness) at large scale and, importantly, to identify target areas for further, fine-scale assessment. Then, fine-scale assessment is conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 4.12: Number of stations and replicate measures completed at Rarumana

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	16	96 transects
Soft-benthos transects (SBt)	12	72 transects
Soft-benthos infaunal quadrats (SBq)	13	104 quadrat groups
Mother-of-pearl transects (MOPt)	8	48 transects
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	5	30 search periods
Reef-front search by walking (RFs_w)	0	0 search period
Sea cucumber day searches (Ds)	5	30 search periods
Sea cucumber night searches (Ns)	2	12 search periods

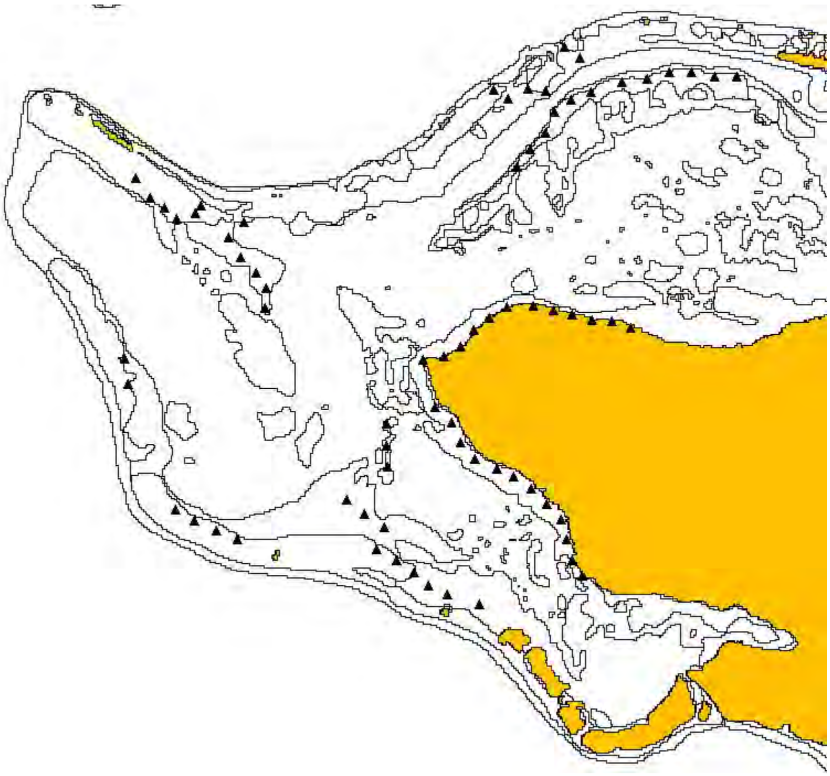

Figure 4.25: Broad-scale survey stations for invertebrates in Rarumana.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

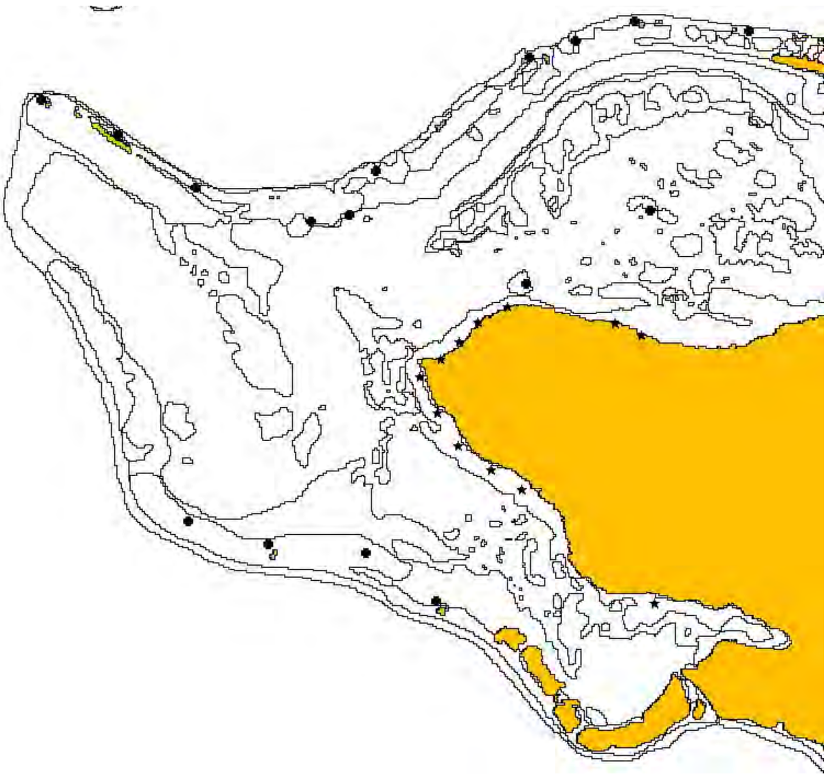

Figure 4.26: Fine-scale reef-benthos transect survey stations (RBt) and soft-benthos transect survey stations (SBt) for invertebrates in Rarumana.
Black circles: reef-benthos transect stations (RBt);
Black stars: soft-benthos transect stations (SBt).

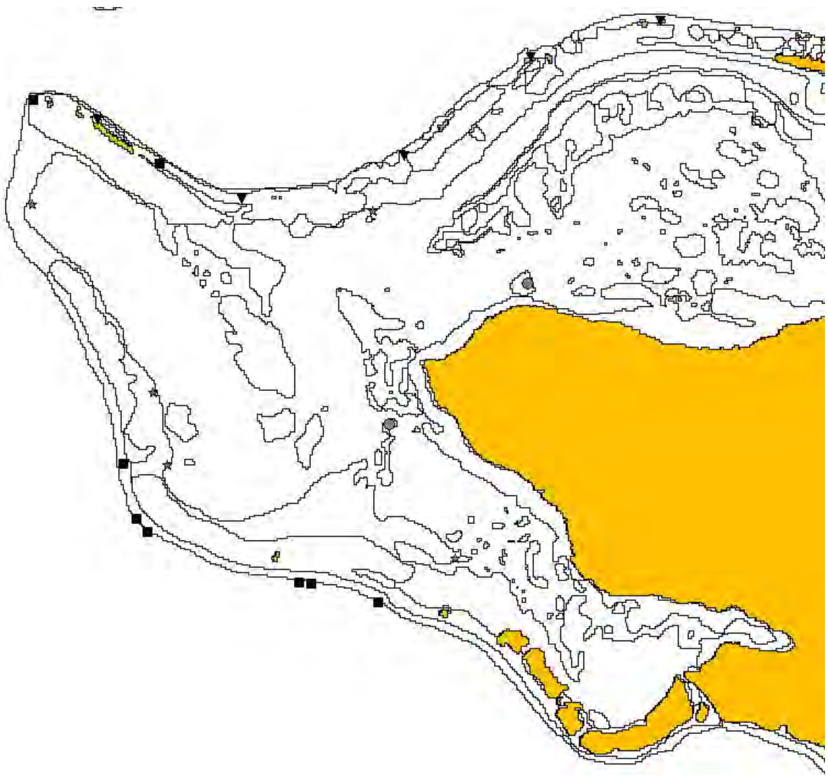

Figure 4.27: Fine-scale survey stations for invertebrates in Rarumana.
Inverted black triangles: reef-front search stations (RFs);
black squares: mother-of-pearl transect stations (MOPt);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Sixty-three species or species groupings (groups of species within a genus) were recorded in the Rarumana invertebrate surveys. These included 13 bivalves, 21 gastropods, 14 sea cucumbers, 7 urchins, 4 sea stars, 1 cnidarian and 2 lobsters (Appendix 4.3.1). Information on key families and species is detailed below.

4.4.1 Giant clams: Rarumana

Broad-scale sampling provided an overview of giant clam distribution throughout the lagoon at Rarumana. Although the lagoon was largely shallow and sandy, reef habitat suitable for giant clams was moderately extensive in scale (8.3 km² of lagoon reef and 5.8 km² of barrier reef and reef slope). This lagoon (63.1 km²), situated to the west of Vona Vona lagoon and south of Blackett Strait, had numerous land and ocean influences. Whereas the system is mostly shallow and protected, with influence from land sources related to Vona Vona Island and surrounds, the Blackett Strait has dynamic oceanic water flows, and there is open ocean to the south and southwest. Land influences in the lagoon (allochthonous inputs and nutrients) were noticeable both north and south of Vona Vona Island, although were most noticeable in the loop of the lagoon to the south. These areas contrasted with the clean reefs bordering the Blackett Strait (from Nusa Aghana Island to Quomu Island) and on the reef front in the south. In general, the reefs at Rarumana provided a range of suitable environments for giant clams.

Reefs at Rarumana held five species of giant clam: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the fluted clam *Tridacna squamosa*, the smooth clam *T. derasa*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. The true giant clam *T. gigas* was not recorded in survey. Records from broad-scale sampling revealed that *T. crocea* had the widest occurrence (found in 9 stations and 24 transects), followed by *T. maxima* (3 stations and 3 transects), *T. squamosa* and *T. derasa* (both recorded in 1 station and 1 transect). *H. hippopus* was not recorded on broad-scale surveys. The average station density of the most common species, *T. crocea*, in broad-scale surveys was low, at 28.7 /ha ±15.4; see Figure 4.28).

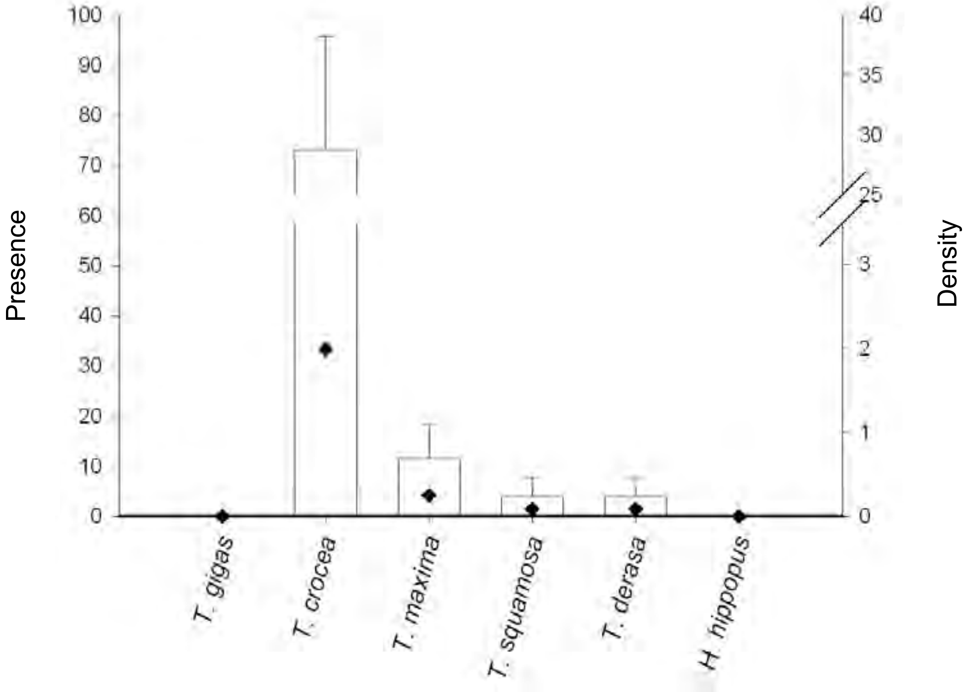

Figure 4.28: Presence and mean density of giant clam species in Rarumana based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 4.29). In these reef-benthos transect assessments (RBt), *T. maxima* was present in 88% of stations at a mean density of 140.6 /ha ±30.9.

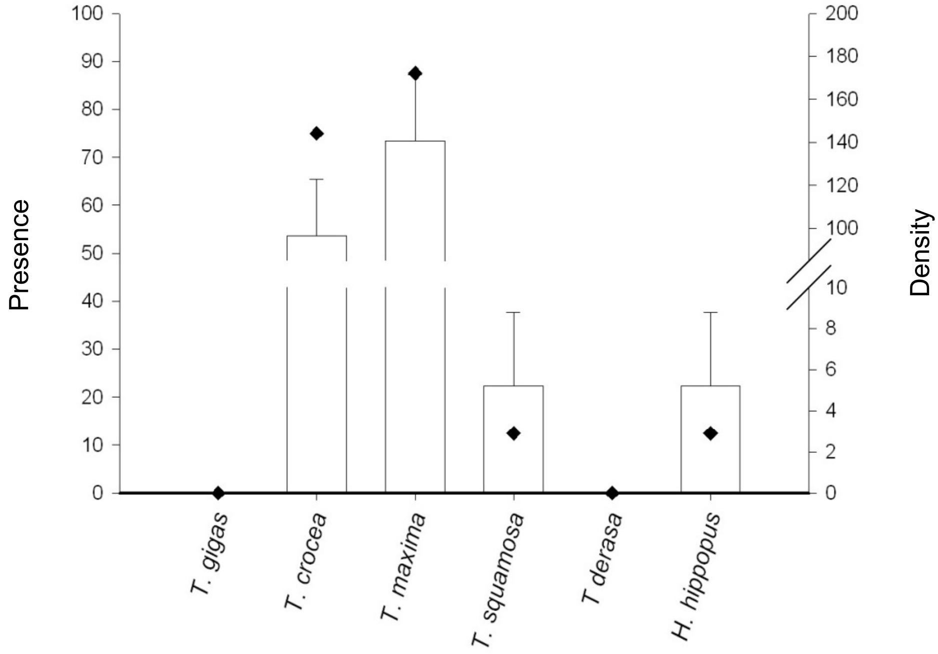

Figure 4.29: Presence and mean density of giant clam species in Rarumana based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

The density of *T. maxima* was consistently higher in RBt stations close to Blackett Strait, but lower in the lagoon and on reefs in the south. A station on reef platform near Nusa Aghana island held the highest *T. maxima* density, a mean of 542 /ha. Two shallow-reef stations held no *T. maxima*. *T. crocea* was at highest density at stations with a more inshore influence (highest RBt station density of 333 /ha).

Of the 310 clam records (from all assessment methods), the average shell length of giant clam records was 12.6 cm ±0.6 for *T. maxima* (n = 107), 7.1 cm ±0.3 for *T. crocea* (n = 94) and 21.9 cm ±4.1 for *T. squamosa* (n = 9). Only two *H. hippopus* clams were measured (11 and 21 cm), and one adult *T. derasa* was noted in broad-scale surveys, but its length was not estimated.

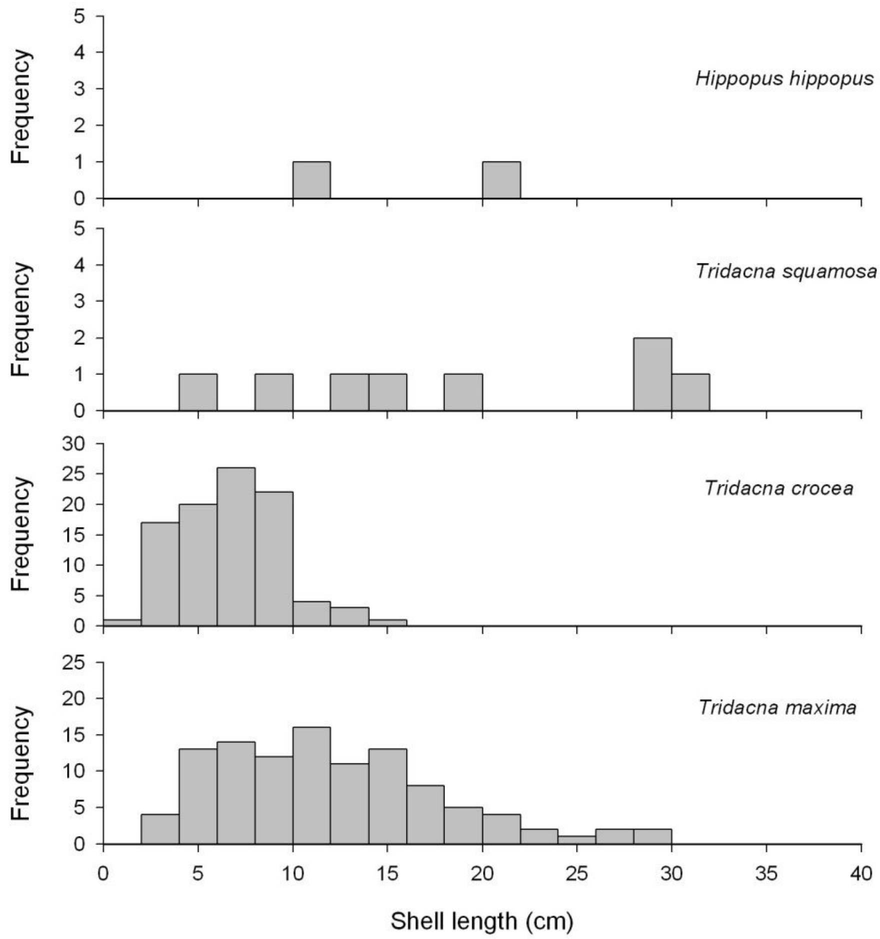

Figure 4.30: Size frequency histograms of giant clam shell length (cm) for Rarumana.

4.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Rarumana

The commercial topshell, *Trochus niloticus*, naturally occurs in Solomon Islands (the natural distribution of trochus stops at Wallis Island to the east.). Suitable reef at Rarumana (24.7 km lineal distance of exposed reef perimeter) provides extensive benthos for adult *T. niloticus*, including areas of back-reef that would provide suitable habitat for juveniles. The exposed barrier-reef shorelines on three sides of the lagoon were subject to dynamic water movement, and were suitable for significant numbers of this commercial species.

PROCFish/C survey work revealed that *T. niloticus* was located in reef bordering Blackett Strait and facing the swells in the south, but was not widespread (Table 4.13).

Table 4.13: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Rarumana
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	0.2	0.2	1/12 = 8	1/72 = 1
RBt	20.8	11.4	4/16 = 25	5/96 = 5
RFs	3.1	2.3	2/5 = 40	3/30 = 10
MOPt	10.4	5.6	3/8 = 38	4/48 = 8
Tectus pyramis				
B-S			0/12 = 0	0/72 = 0
RBt	93.8	30.8	12/16 = 75	25/96 = 26
RFs	14.1	11.3	3/5 = 60	8/30 = 27
MOPt	62.5	15.2	7/8 = 88	15/48 = 31
Pinctada margaritifera				
B-S	4.2	1.4	6/12 = 50	10/72 = 14
RBt	72.9	16.8	13/16 = 81	23/96 = 24
SBt	3.5	3.5	1/12 = 8	1/72 = 1
RFs	11.8	3.0	5/5 = 100	9/30 = 30
MOPt	7.8	3.8	3/8 = 38	3/48 = 6

B-S = broad-scale survey; RBt = reef-benthos transect; SBt = soft-benthos transect; RFs = reef-front search; MOPt = mother-of-pearl transect.

As the trade winds come from the southeast, the barrier reef to the south of the lagoon is impacted by larger swells, while much of the northerly reefs are protected. This is not the case for the equatorial monsoon swell, which impacts northerly reefs between the months of December and March.

Despite the suitable habitat and wide-ranging presence of trochus, no high-density aggregations were noted, and survey stations that held trochus were at low density (total n = 17).

These broadcast spawners require males and females to be at close proximity (at high density) to stimulate and facilitate reproduction. The fishery should adopt a threshold of ~500 shells/ha as the minimum density required before main aggregations can be considered ‘ready’ for commercial fishing. Currently trochus density records from Rarumana indicate a significant shortfall in overall abundance.

Shell size also gives an important indication of the status of stocks, by highlighting the level of new recruitment into the fishery, which has implications for the numbers of trochus entering the capture size classes in the following two years. Young trochus enter the fishery stock at ~8 cm, when they are ~3 years old. Typically, trochus >11 cm are common in survey recordings, as these shells are less cryptic than smaller shells and, due to their prolific spawning potential, are protected from fishing so they can contribute to future harvests.

The mean size (basal width) of trochus at Rarumana was 9.1 cm ±0.4 (n = 17; see Figure 4.31). No small trochus (<5 cm basal width) were recorded at Rarumana. Despite this component of the stock generally being less visible among rubble and boulders, younger shells are normally picked up in surveys in small amounts and more commonly from about 5.5 cm, when they emerge to join the main stock. As can be seen from the length frequency graph, young trochus were not commonly recorded in Rarumana, and large shells were also at low density. In some well managed fisheries, shells >11 cm make up 20% of the measured stock.

In Figure 4.31, the dotted line highlights the 12 cm basal size mark, when larger mature size classes of shell would be protected from fishing under Solomon Islands regulations. It is obvious from these results that shells are not living to reach this size due to over fishing of legal size classes, or that trochus are being taken from the fishery even if they are over the legal size.

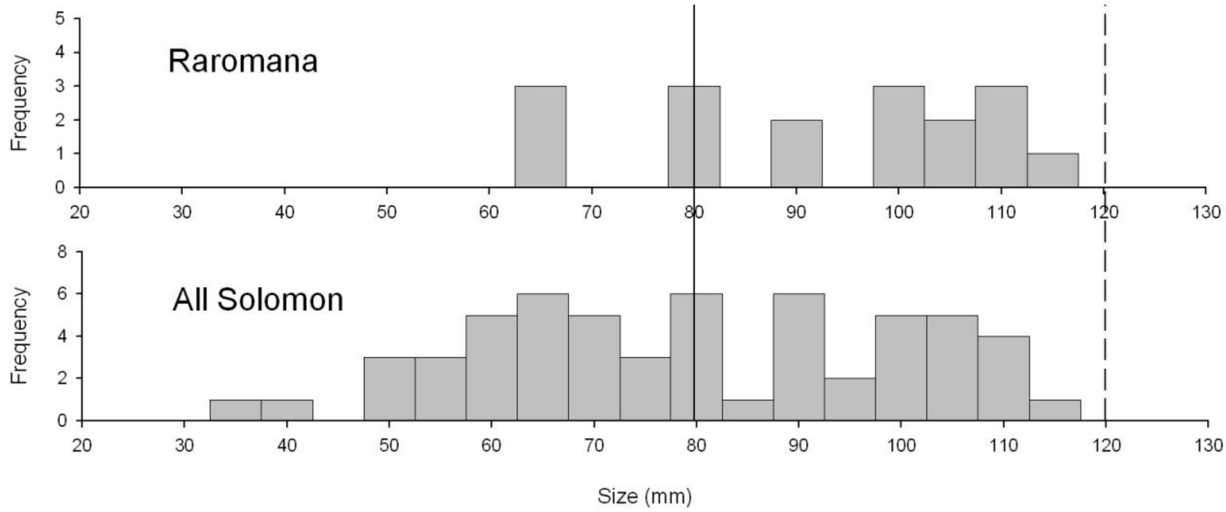

Figure 4.31: Size frequency histograms of trochus shell base diameter (cm) for Rarumana.

The suitability of reefs for grazing gastropods was highlighted by results for the false trochus or green topshell (*Tectus pyramis*). This closely related species (with a similar life habit) was noted in five times the number of shallow-water reef transects than trochus, at 4.5 times the density. This less valuable species of algal-grazing topshell had a mean shell size of 5.5 cm ±0.1 (n = 70) and was recorded at moderately high density in some stations (>200 /ha in 2 of the 16 RBt stations).

The blacklip pearl oyster, *Pinctada margaritifera*, is generally a cryptic species, found from shallow to deep water (<1–50 m) and sparsely distributed in open lagoon systems like the one found at Rarumana. However, blacklip were common in surveys (n = 51), being recorded in 81% of RBt stations and all reef-front search stations. Previous studies of blacklip pearl oyster settlement in this area have shown that longshore currents running from the reef in front of Makuti Island all along Blackett Strait to Hathorn Sound (near Noro) carry the larvae of blacklip, which can be settled in commercial densities on artificial collectors. Blacklip pearl oysters noted in surveys ranged in size from 8 to 15 cm (mean 10.1 cm ±0.5, n = 18).

No greensnail, *Turbo marmoratus*, were recorded in surveys.

4.4.3 Infaunal species and groups: Rarumana

Soft-benthos areas were common along the coastal margins of Rarumana, and concentrations of in-ground resources (shell 'beds') were noted. Thirteen infaunal stations were assessed for resource species such as *Anadara* spp., *Periglypta* spp. and *Strombus* spp. shells, although no venus shells (*Gafrarium* spp.) were noted.

Anadara spp. were noted at 46% of stations and 21% of quadrat groups, at an average station density of 1 /m^2 ±0.3. Unfortunately, no length recordings were collected so no inferences can be made from the size profile of these shells. Other species of interest were rare; *Periglypta puerpera* was recorded in one station (overall mean density of 0.04 /m^2), whereas *Strombus luhuanus*, which burrows into surface sediments, was relatively common (recorded in 54% of stations, mean station density of 1.07 /m^2).

4.4.4 Other gastropods and bivalves: Rarumana

Seba's spider conch, *Lambis truncata* (the larger of the common spider conchs), was absent in surveys, although *L. lambis* and the strawberry or red-lipped conch *Strombus luhuanus* were more common. *L. lambis* was noted in 33–44% of B-S, SBt and RBt stations, reaching an average of 20–26 /ha in the two finer-scale surveys. There was a large range of *Lambis* species present (*L. scorpius*, *L. millepeda* and *L. chiragra*). Apart from the relatively high density of *S. luhuanus* in some soft-infaunal assessments, they were also noted in 38% of RBt stations at a mean density of 41.7 /ha ±16.6.

Although the large *Turbo marmoratus* was not noted, a wide range of small turban shells were recorded in survey (e.g. *Turbo argyrostomus*, *T. chrysostomus*, *T. setosus* and *T. petholatus*). None were very common, although *T. argyrostomus* was recorded in 31% of shallow-reef transect stations (mean density 28.6 /ha ±14.1). Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Conus*, *Cypraea*, *Latirolagena*, *Thais*, *Tutufa* and *Vasum*) were also recorded during independent surveys (Appendices 4.3.1 to 4.3.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa*, *Periglypta*, *Pteria* and *Spondylus*, are also in Appendices 4.3.1 to 4.3.7. No creel survey was conducted at Rarumana.

4.4.5 Lobsters: Rarumana

Rarumana had 24.7 km (lineal distance) of exposed fringing reef. This reef (and lagoon patch-reef) provided a suitable habitat for lobsters. Lobsters are an unusual invertebrate species that can recruit from near and distant reefs as their larvae drift in the ocean for 6–12 months (up to 22 months) before settling as transparent miniature versions of the adult (pueruli, 20–30 mm in length).

There was no dedicated night reef-front assessment of lobsters (See Methods.) but, nevertheless, surveys still recorded *Panulirus* sp. (n = 15) and two sand lobsters, the banded prawn killer, *Lysiosquillina maculata.* No slipper lobsters were noted.

4.4.6 Sea cucumbers[12]: Rarumana

As part of a major shallow-water lagoon system, connected to an extensive land mass (69.2 km^2), the system at Rarumana provided extensive areas of protected reef margins and mixed hard- and soft-benthos habitat that is suitable for sea cucumbers. There was significant land and riverine influence close to shore and in the lagoon, but oceanic factors and dynamic water movement flushed the outer lagoon and reef bordering Blackett Strait (N) and the

[12] There has been a recent variation to sea cucumber taxonomy which has changed the name of the black teatfish in the Pacific from *Holothuria (Microthele) nobilis* to *H. whitmaei*. There is also the possibility of a future change in the white teatfish name. This should be noted when comparing texts, as in this report the 'original' taxonomic names are used.

Solomon sea (S). The benthos varied from inshore to offshore, with heavy epiphytic growth close to Rarumana village in the closed loop of the lagoon, and 'cleaner' environments closer to the barrier reefs, especially to the west. Outside the barrier reef, the benthos shelved relatively steeply on the northern shore, without shoals (large areas of shallow, offshore reef platform). In the west, there was a more extended reef slope, with a more shallow sloping reef front.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 4.14, Appendices 4.3.2 to 4.3.9; see also Methods). At Rarumana, 14 commercial species of sea cucumber were recorded during in-water assessments (Table 4.14). The range of sea cucumber species recorded in Rarumana was lower than might be expected considering the range of environments present and the geographical position of Solomon Islands, which is close to the centre of biodiversity.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*) were not recorded in broad-scale surveys. This is an unusual result, as leopardfish can be considered an indicator species for broad-scale assessments, as it is visible and widespread across most lagoon sites. For example, *B. argus* was recorded during broad-scale surveys at all sites in PNG, Fiji, FSM, Marshall Islands, New Caledonia, Vanuatu, even French Polynesia. Distribution and average density records for this species when noted in shallow-reef transect surveys or in reef-front searches were indicative of a highly impacted stock (<3 /ha). Black teatfish (*Holothuria nobilis*), a high-value species that is highly susceptible to over fishing, was completely absent from all records. This species is another good indicator of fishing pressure, and as this species was absent from all surveys despite the availability of extensive areas of suitable environment, the assumption is that fishing pressure has decimated stocks.

The same result was noted for the fast growing and medium/high-value greenfish (*Stichopus chloronotus*), which was not found at any stations in Rarumana. Surf redfish (*Actinopyga mauritiana*), another easily targeted species that should be common on the outer-reef fronts near Rarumana, was also absent. This species was noted in low density in Nggela and Marau, but can reach commercial densities of 500–600 /ha in parts of Guadalcanal protected from fishing, and also in French Polynesia and Tonga.

In more protected areas of reef and soft benthos in areas of fringing reef that were less dynamic, blackfish (*Actinopyga miliaris*) and curryfish (*Stichopus hermanni*) were recorded in low density. Even low-value lollyfish (*Holothuria atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*) were uncommon and at low density. Premium-value sandfish (*H. scabra*), which was recorded at sites in Vona Vona in the late 1990s, was absent from survey records.

Deeper-water assessments (30 searches of five minutes, average depth 17.6 m, maximum depth 25 m) were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), amberfish (*T. anax*) and elephant trunkfish (*H. fuscopunctata*). Stations were selected where there were both suitably dynamic water movement and oceanic-influenced benthos. *H. fuscogilva* was present in 60% of surveys. White teatfish were not at high density (average 5 /ha) and a total of 8 individuals were noted at the stations surveyed. There were anecdotal reports that transient fishers from Gizo were using compressed air to dive for these high-value species in the passage and edges of the lagoon at night. The lower-value and generally more common amberfish (*T. anax*) was absent from survey records.

4.4.7 Other echinoderms: Rarumana

The edible collector urchin (*Tripneustes gratilla*) was recorded in a number of different survey techniques at low density (total n = 14). Slate urchins (*Heterocentrotus mammillatus*) were uncommon (n = 9), as were the larger black *Echinothrix* spp. (also edible and a habitat indicator species). *Echinothrix diadema*, the more common of the two species noted, was only recorded in 38% of RBt stations, at a moderate average density of 190.1 ±108 /ha. *Echinometra mathaei* and *Diadema* spp. were also noted at moderate densities (Appendices 4.3.1 to 4.3.7).

Starfish were common around Rarumana; the common blue and yellow starfish (*Linckia laevigata* and *L. guildingi*) were recorded in moderately large numbers (n = 448) and were common across broad-scale surveys (recorded in 75% of broad-scale stations). Pincushion stars (*Culcita novaeguineae*) were less common (recorded in 42% of broad-scale stations) and were not at high density (3.9 /ha ±1.5). Another, more serious, threat to corals (coralivore, coral-eating starfish), the crown of thorns star (*Acanthaster planci*, COTS) was also not common, with a total of eleven recorded in all surveys. At no survey stations was the density of COTS even close to being high enough to qualify for the definition of ‘incipient outbreak’, meaning the density at which coral damage is likely (0.22 adults per 2-minute manta tow; or >30 adult and sub-adults /ha).

Table 4.14: Sea cucumber species records for Rarumana

Species	Common name	Commercial value [5]	B-S transects n = 72			Reef-benthos stations n = 16; SBt = 12			Other stations RFs = 5; MOPt = 8			Other stations Ds = 5; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H				2.6	41.7	6				8.9	8.9	100 Ns
Actinopyga mauritiana	Surf redfish	M/H												
Actinopyga miliaris	Blackfish	M/H										17.8	35.6	50 Ns
Bohadschia argus	Leopardfish	M				2.6	41.7	6 RBt	0.8	3.9	20 RFs			
Bohadschia graeffei	Flowerfish	L	0.7	16.7	4				1.6	3.9	40 RFs	0.7	3.6	20 Ds
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	1.6	16.7	10	2.6 10.4	41.7 125.0	6 RBt 8 SBt				0.7 22.2	3.6 44.4	20 Ds 50 Ns
Holothuria atra	Lollyfish	L	5.8	27.7	21	2.6 20.8	41.7 62.5	6 RBt 33 SBt	0.8 2.6	3.9 20.8	20 RFs 12.5 MOPt			
Holothuria coluber	Snakefish	L										57.8	57.8	100 Ns
Holothuria edulis	Pinkfish	L	1.4	16.7	8				4.7 5.2	5.9 41.7	80 RFs 13 MOPt	1.4 31.1	3.6 31.1	40 Ds 100 Ns
Holothuria fuscogilva [4]	White teatfish	H	0.2	16.7	1							5.0	8.3	60 Ds
Holothuria fuscopunctata	Elephant trunkfish	M							2.6	20.8	13 MOPt	0.7	3.6	20 Ds
Holothuria nobilis [4]	Black teatfish	H												
Holothuria scabra	Sandfish	H												
Stichopus chloronotus	Greenfish	H/M												
Stichopus hermanni	Curryfish	H/M	0.2	16.7	1									
Stichopus horrens	Peanutfish	M/L	0.2	16.7	1									
Stichopus vastus	Brown curryfish	H/M												
Synapta spp.	-	-												
Thelenota ananas	Prickly redfish	H				2.6	41.7	6 RBt				0.7	3.6	20 Ds
Thelenota anax	Amberfish	M												

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) *nobilis* to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published. [5] L = low value; M = medium value; H= high value; H/M is higher in value than M/H; B-S transects= broad-scale transects; SBt = soft-benthos transect; RFs = reef-front search; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

4.4.8 Discussion and conclusions: invertebrate resources in Rarumana

A summary of environmental, stock-status and management factors for the main fisheries is given below. Please note that information on other, smaller fisheries and the status of less prominent species groups can be found in the body of the invertebrate chapter.

In summary, giant clam habitat, distribution, density and shell length information revealed the following:

- The lagoon at Rarumana was very shallow and sandy in nature, but was bordered by lines of reef on the north, south and west. The varied structure and dynamic water movement in some areas presented suitable habitat for the full range of giant clams found in Solomon Islands.

- Giant clam presence and density was moderate considering the nature of the environment. The elongate clam, *Tridacna maxima*, and boring clam, *T. crocea*, were in relatively high densities in some areas. *T. squamosa* and *Hippopus hippopus* were only recorded at densities lower than expected and both were rare. The same could be said for *T. derasa*, which is becoming critically depleted across much of the Pacific. *T. gigas* was not recorded and is considered 'commercially extinct'[13].

- Although *T. maxima* and *T. squamosa* displayed a relatively 'full' range of size classes, larger shell sizes of the boring clam (*T. crocea*) were noticeably impacted. The presence of young clams indicates that successful spawning and recruitment is still occurring, but the low abundance of clams and scarcity of large sizes suggest clams are impacted by fishing.

Data on MOP distribution, density and shell size suggest the following:

- Local reef conditions at Rarumana constitute an extensive and good habitat for adult and juvenile trochus.

- Trochus were widely distributed at reefs around Rarumana that were easily accessible for fishers. The general outlook for the fishery is poor as the density of trochus on reefs is very low and no high-density spawning aggregations were identified in survey.

- Most eggs are produced by the largest individuals of a population. This survey shows that this component of the population is currently depleted. Trochus reach the larger size classes (>11 cm basal width) at ≥6 years of age (from shells that would need to survive at least three years in the fishery under the current management scenario). The lack of large, older shells, which have the greatest potential to fuel future populations to support the fishery, means that it may take ≥5 years for stocks to recover to a state where they are again productive.

- Size-class information reveals that recruitment is still occurring but is weak. Previous harvests have comprehensively impacted stock density in most areas, and this is negatively impacting the potential for the creation of young trochus.

[13] Commercially extinct means in this context that the clams were at such a low density as to make them unavailable for any trade and in danger of complete local extinction.

- The low commercial value green topshell, *Tectus pyramis*, which has a similar life habit to trochus, was relatively common.

- Green snail (*Turbo marmoratus*), a species commonly found in Rarumana in the past, was not noted in this survey and is considered commercially extinct in Rarumana.

- Blacklip pearl oysters, *Pinctada margaritifera*, were common at Rarumana and support previous research that this area of Solomon Islands is highly suited for this species, and has potential for the development of pearl farming based on wild-spat collection (Friedman and Bell 1999; Oengpepa *et al.* 2006).

In summary, the distribution, density and length recordings of sea cucumbers at Rarumana reveal the following:

- The range of protected shallow-water and deeper-water lagoon and reef habitats made Rarumana a good site for a full range of sea cucumber species typical of Solomon Islands.

- Although Rarumana is close to the centre of biodiversity in the Pacific, the number of commercial sea cucumber species recorded was low (n = 14). Many species that are typically recorded in our Pacific surveys (even if they are depleted through heavy fishing) were absent from the site.

- Distribution data showed that sea cucumbers' presence was patchy, even for species that are typically found spread across varied habitats. The densities of commercial species that were recorded were extremely low.

- The picture of most sea cucumber species and species groups presented by these records is extremely bleak. The long history of the sea cucumber fishery in the Pacific suggests that these fisheries can bounce back from heavy fishing, but the Rarumana stocks are some of the most depleted found in the PROCFish Pacific overview.

4.5 Overall recommendations for Rarumana

- Community fisheries management projects need to be established, to ensure a precautionary approach to resource use. Marine protected areas should be established around the island to maintain biodiversity and productivity of local resources.

- Actions need to be taken to reduce and control poaching activities.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Rarumana fishing ground that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- The subsistence needs of the community for finfish and invertebrates are extremely high and the exploitation level of a number of selected target invertebrate species is also high. Rather than further exploiting these marine resources, options need to be explored for adding value to fishery products through preservation and processing methods, to improve their marketing and create alternative income opportunities for local people.

- The high dependency on marine resources for food will remain and its impact on the Rarumana marine resources needs to be wisely managed, with finfish and invertebrate stocks carefully monitored in order to maintain the present level of fisheries for sustenance and social reasons.

- Cooperation among governmental, NGOs and other external institutions, and the Rarumana community needs to be fostered in order to ensure the success of improved fisheries management.

- For successful management, giant clams need to be maintained at higher density and include larger-sized individuals to spawn and reproduce effectively.

- Strict protection of trochus stocks is needed until the density of trochus at the main aggregations reaches 500–600 /ha. There is presently no scope for commercial trochus fishing at Rarumana, until the recommended threshold is reached and where managers might consider commercial fishing.

- Drastic management actions are needed to ensure there is a future for the sea cucumber fishery in Rarumana, which is among the most depleted in the entire PROCFish study across the Pacific. The fishery will need to be closed for a considerable period (up to 10 years) in the hope of re-building viable productivity in the fishery.

5. PROFILE AND RESULTS FOR CHUBIKOPI

5.1 Site characteristics

Chubikopi is located on Marovo Island in Western Province (Figure 5.1). Marovo is a high island cut off from the main island of Vangunu by a deep channel that is fairly narrow and lined with mangroves. The village of Chubikopi is located in the NE part. Two other villages take up the northern and western parts of the island. The fishing grounds are marked off by two passes, i.e. a deep one in the northeast and a very shallow one in the north.

The survey site on Chubikopi includes Marovo Island, surrounding islets in the lagoon and barrier islands north of the Karikana passage (Karikana Islands behind Charapoana). Marovo lagoon is semi-enclosed by a number of long, slender barrier islands. On the ocean-facing side of these barrier islands are steep vertical walls, which drop straight into the abyss. Deep channels between these barrier islands act as a medium of water exchange between the lagoon and the ocean. In general, water clarity in the areas surveyed was low or murky, increasing in turbidity from behind the barrier islands to the mainland. Waters immediately outside of the barrier islands or ocean-facing are very clear by comparison. Thicker mangrove forests are found on Marovo Is and the mainland, while other islets in the lagoon and the barrier islands have little mangrove forests. Reef flats surrounding the islands including the inner, mid and outer parts of the study sites are quite narrow. There is high coral diversity and healthy coral growth; however, live-coral cover was low-to-moderate.

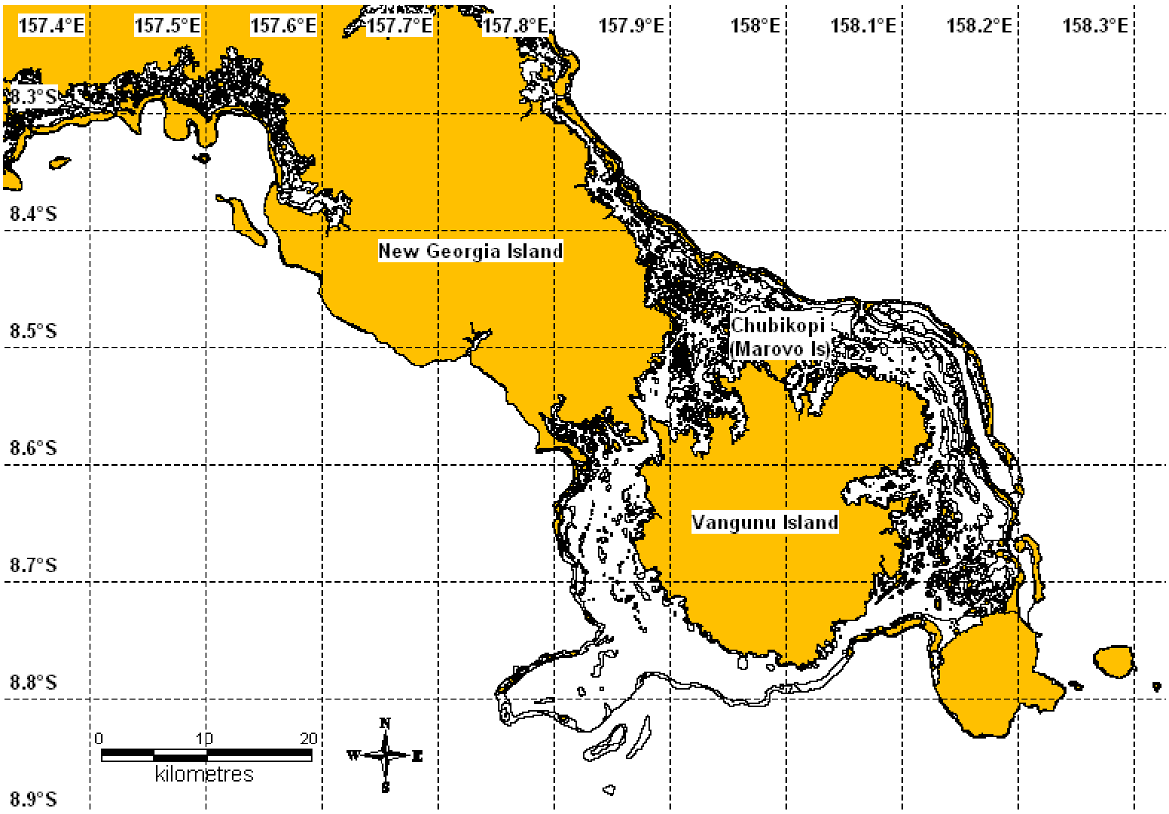

Figure 5.1: Map of Chubikopi.

5.2 Socioeconomic surveys: Chubikopi

Socioeconomic fieldwork was carried out in Chubikopi, located in the Marovo lagoon of Solomon Islands' Western Province on 15–28 August 2006. The survey included three villages, namely Chubikopi, Chea and Ruruku. Survey results are referred to 'Chubikopi' in the following. Two of these three villages, i.e. Chea and Ruruku, are involved in the Seventh Day Adventist (SDA) religion, a fact that limits fisheries to finfish and restricts church members from collecting, consuming and selling invertebrates. Western Province is a predominantly rural area with little access to urban markets. Gizo is the nearest urban market centre in Western Province, but is only accessible by plane or by a 8–10 hour boat journey. Air transport is irregular and expensive and travel by boat is also expensive. In addition, marketing is limited due to the lack of proper ice-making or other preservation facilities. Marketing of fisheries produce is mainly determined by the fortnightly visits of middlemen and agents who buy catch for selling at Honiara, the capital city and main centre in Guadalcanal. The communities reported that the fish price has stagnated over the past years. However, as people lack alternatives, catches are still sold at the same price as years ago. A few households also use trochus shells for generating cash income, either by selling to middlemen or agents, or selling at Honiara if the possibility arises. Some catch may be sold to the nearby tourist resort; however, this demand is rather small. In addition, the presence of several logging companies that exploit the forest resources around the Marovo lagoon allows fishers to sell a small proportion of the catch to the mainly Chinese workers and traders.

The Chubikopi community has a resident population of 1727 people with a total of 260 households. A total of 42 households (10 Chea, 7 Chubikopi, 10 Rukutu), which is 16% of total households in the community, were surveyed, with almost all (98%) of these households being engaged in some form of fishing activities. In addition, a total of 54 finfish fishers (34 males and 20 females) and 46 invertebrate fishers (17 males and 29 females) were interviewed. The average household size is 5–7 people, with Chubikopi having the largest average household size (7 people) and Chea the smallest (5 people). Household interviews focused on the collection of general demographic, socioeconomic and consumption data.

5.2.1 The role of fisheries in the Chubikopi community: fishery demographics, income and seafood consumption patterns

Our results (Figure 5.2) suggest that 'other' sources, mainly wood carving and handicrafts, are by far the main source of household income. The Marovo lagoon community is known for its wooden carvings and handicrafts, and artifacts are sold to visiting tourist boats, resorts, and to Gizo or Honiara. While ~55% of households stated that 'other' sources (carving, selling of small items including tobacco, betel nut, bread, etc.) determine their main income, only ~17% of all households stated either fisheries or salaries as their first income source. Agriculture is the first source of income for about 11% of households. Fisheries do, however, play the most important role as complementary, secondary income (~33%), while other income sources (carving, handicrafts) and agriculture make up 21% and 19% respectively. About 33% of households have one pig, and about half of all households have a couple of chickens.

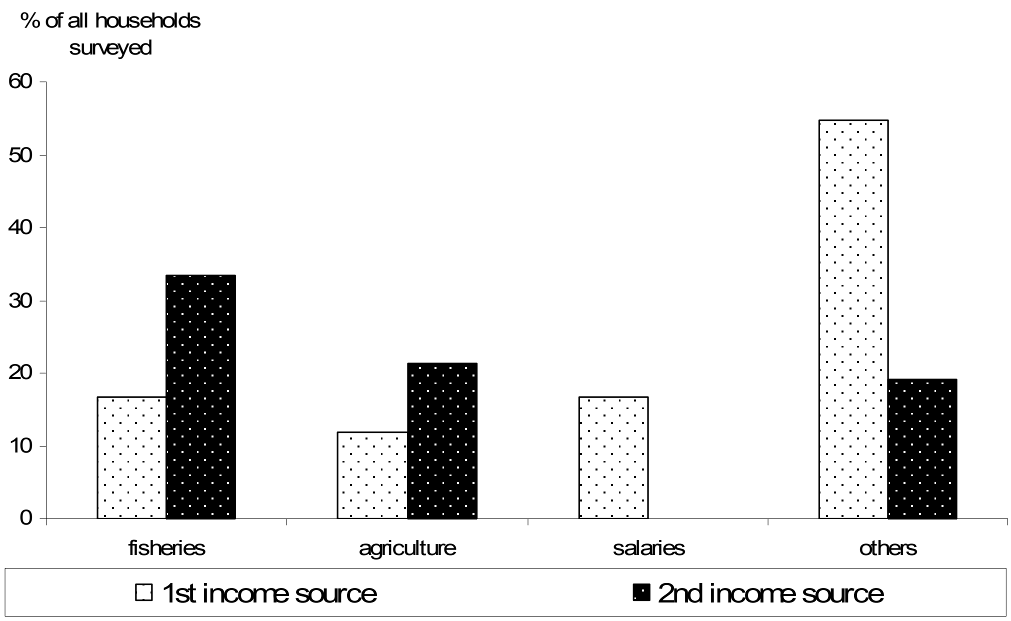

Figure 5.2: Ranked sources of income (%) in Chubikopi.
Total number of households = 42 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

Our results (Table 5.1) show that annual household expenditures are low at an average of USD 370. Remittances are not an important component of Chubikopi's household income, with 10% of households in Chea and 4% of households in Chubikopi receiving remittances. The households that receive remittances get an average of USD ~80 /year only. This situation differs from other communities surveyed in Solomon Islands, where remittances play a much more important role.

Table 5.1: Fishery demography, income and seafood consumption patterns in Chubikopi

Survey coverage	Site (n = 42 HH)	Average across sites (n = 182 HH)
Demography		
HH involved in reef fisheries (%)	97.6	99.5
Number of fishers per HH	2.93 (±0.20)	3.24 (±0.12)
Male finfish fishers per HH (%)	27.6	17.0
Female finfish fishers per HH (%)	9.8	2.2
Male invertebrate fishers per HH (%)	0.8	0.2
Female invertebrate fishers per HH (%)	13.8	9.0
Male finfish and invertebrate fishers per HH (%)	24.4	39.6
Female finfish and invertebrate fishers per HH (%)	23.6	32.1
Income		
HH with fisheries as 1st income (%)	16.7	30.2
HH with fisheries as 2nd income (%)	33.3	32.4
HH with agriculture as 1st income (%)	11.9	33.5
HH with agriculture as 2nd income (%)	21.4	31.9
HH with salary as 1st income (%)	16.7	11.0
HH with salary as 2nd income (%)	0.0	0.5
HH with other source as 1st income (%)	54.8	24.2
HH with other source as 2nd income (%)	19.0	12.1
Expenditure (USD/year/HH)	370.93 (±27.83)	404.22 (±22.58)
Remittance (USD/year/HH) (1)	81.30 (±27.10)	258.35 (±55.85)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	109.55 (±7.89)	104.78 (±4.00)
Frequency fresh fish consumed (times/week)	3.58 (±0.09)	3.57 (±0.05)
Quantity fresh invertebrate consumed (kg/capita/year)	8.51 (±2.36)	10.13 (±4.00)
Frequency fresh invertebrate consumed (times/week)	0.94 (±0.09)	1.20 (±0.06)
Quantity canned fish consumed (kg/capita/year)	4.55 (±0.51)	3.75 (±0.34)
Frequency canned fish consumed (times/week)	1.05 (±0.10)	0.85 (±0.07)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	88.1	95.6
HH eat canned fish (%)	95.2	75.3
HH eat fresh fish they catch (%)	97.6	97.6
HH eat fresh fish they buy (%)	21.4	21.4
HH eat fresh fish they are given (%)	71.4	71.4
HH eat fresh invertebrates they catch (%)	71.4	71.4
HH eat fresh invertebrates they buy (%)	0.0	0.0
HH eat fresh invertebrates they are given (%)	47.6	47.6

HH = household; (1) average sum for households that receive remittances; numbers in brackets are standard error.

Survey results indicate an average of 3 fishers per household and, when extrapolated, the total number of fishers in Chubikopi is 761, including 402 males and 354 females. Among these are 210 exclusive finfish fishers (210 males, 74 females), 111 exclusive invertebrate fishers (6 males, 105 females), and 365 fishers who fish for both finfish and invertebrates (186 males, 179 females). Most (~88%) households own a boat, and most (~87 %) are non-motorised canoes; only ~13% are equipped with an outboard engine.

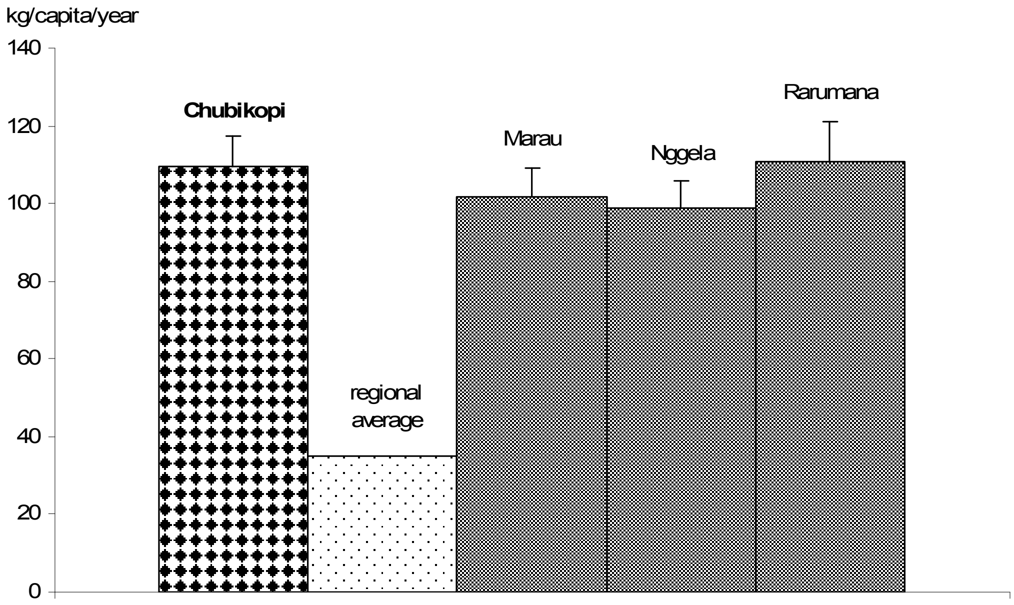

Figure 5.3: Per capita consumption (kg/year) of fresh fish in Chubikopi (n = 42) compared to the regional average (FAO 2008) and the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

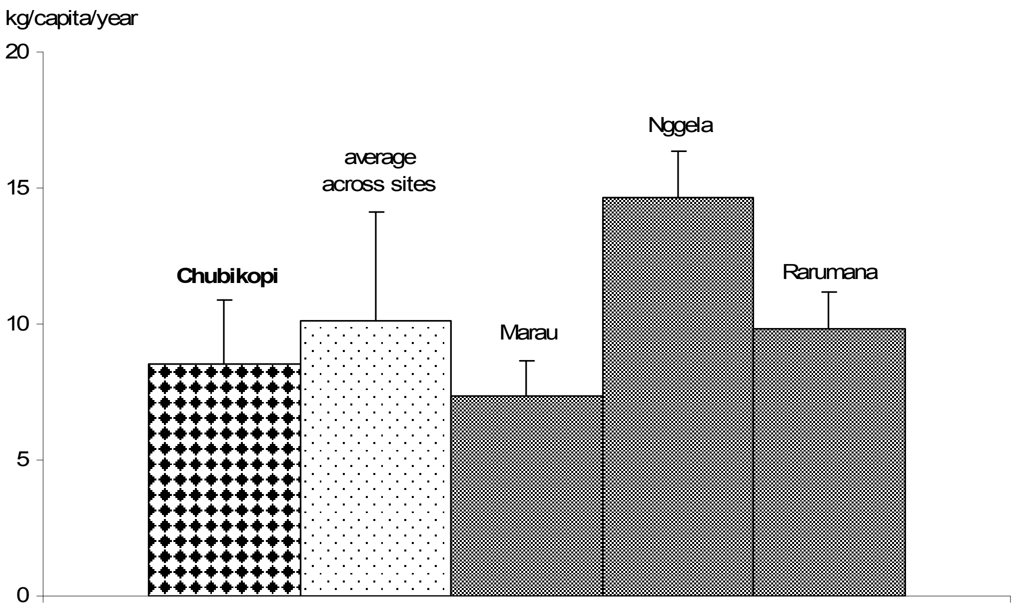

Figure 5.4: Per capita consumption (kg/year) of invertebrates (meat only) in Chubikopi (n = 42) compared to the other three PROCFish/C sites in Solomon Islands.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Consumption of fresh fish is high at ~110 kg/person/year, which is similar to the average across all four study sites in Solomon Islands, but significantly higher than the assumed average for Solomon Islands of 40 kg/person/year (Gillet and Lightfoot 2001) to 45.5 kg/person/year (FAO 2008), or the regional average of ~35 kg/person/year (Figure 5.3). By comparison, consumption of invertebrates (edible meat weight only) (Figure 5.4) is moderate at 8.5 kg/person/year. Canned fish (Table 5.1) adds 4.5 kg/person/year to the protein supply from seafood. Canned fish is expensive given the low household cash income and expenditure levels. The consumption pattern of seafood found in Chubikopi highlights the fact that people do not have access to urban markets, that they live a rural and traditional lifestyle, and that revenues are low as suggested by the low average annual household expenditure level.

Comparing results obtained for Chubikopi to the average figures across all four study sites surveyed in Solomon Islands, people of the Chubikopi community eat fresh fish, invertebrates and canned fish about as often as found on average. However, while the consumption of fresh fish is comparative, the community eats less invertebrates and a bit more canned fish than average. Chubikopi people are the same as the average across all study sites in terms of the proportion of fish and invertebrates that they consume and that they buy, or that is caught by somebody living in the household. Sharing seafood among community members on a non-monetary basis is very common but less practised for invertebrates than for finfish. Wood carving and other handicrafts play a much greater role than average, and fisheries and agriculture a lesser role for generating first income. Household expenditure levels and remittances received in Chubikopi are substantially lower than elsewhere. By comparison, boat ownership and the dominance of non-motorised canoes does not vary much from the average found in the other sites surveyed in Solomon Islands.

5.2.2 Fishing strategies and gear: Chubikopi

Degree of specialisation in fishing

A couple of fisheries management interventions have already been initiated or carried out. For example, in the Chea community, FSPI has set up a fisheries reserve around one of the outer and uninhabited islands. In addition, although not numerous, there are traditional and governmental *tabu* and regulations, although these are coupled with a lack of awareness of their needs, objectives, and the need for compliance. This is particularly surprising as about 85% of all land and marine areas are held under 'traditional' or 'customary' tenure systems and therefore are subject to local communities' user and management rights. The governmental banning of bêche-de-mer harvesting and the collection of aquarium trade species, mainly live coral, is considered as a deprivation from income sources rather than a necessary fisheries management intervention. The International Waters Programme (IWP) has worked in the village of Chea to find a cost-effective way to improve local management, especially of important species. As a result, a marine protected site has been established at one of the uninhabited islands a good distance from the village.

While fishing is not one of the most important income sources, it is still one of the most important sources of protein and calories. Fisheries produce is also important for social cohesion as it is regularly exchanged among community members as a gift. There are no explicit traditional gender roles, except the traditional demand for division of labour. Females are heavily involved in gardening, and also go fishing for both finfish and invertebrates on a regular basis. Children also participate in subsistence fisheries on a regular basis, and while accompanying their parents they learn traditional skills and knowledge. This is supported by Figure 5.5, i.e. while more males specialise in catching finfish only, and more females than males exclusively collect invertebrates, a substantial share of both males and females fish for both finfish and invertebrates.

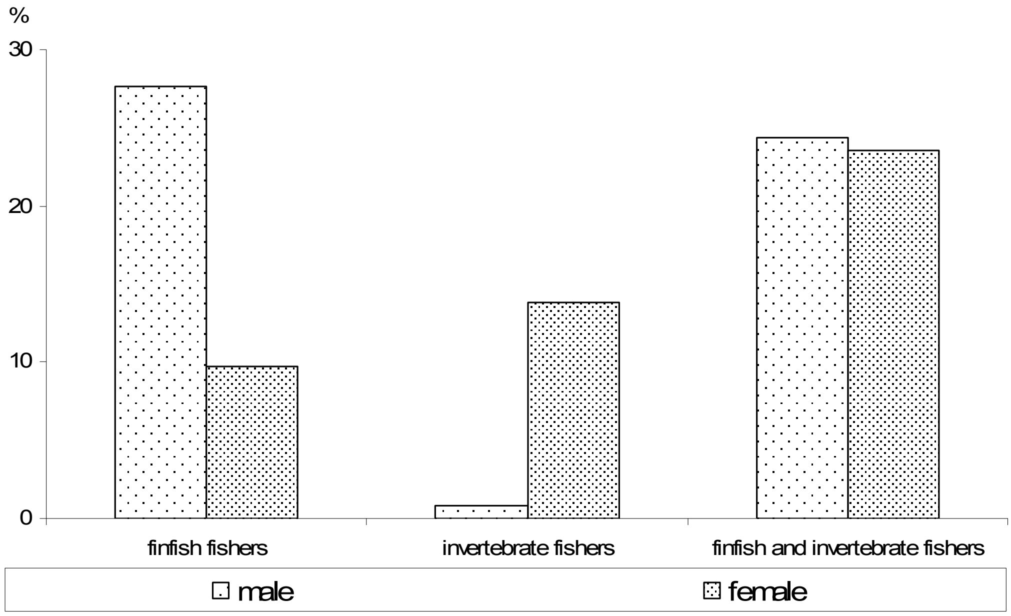

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Chubikopi.
All fishers = 100%.

Targeted stocks/habitat

Because the lagoon is the main thoroughfare, canoes are used for transport and fishing. Most of the fishing is done in the coastal areas and lagoon (~68% of all male fishers and 100% of female fishers). If the outer reef is targeted, travel time is longer, exposure to sea and weather conditions is higher and only males (44%) target these habitats. Table 5.2 also shows that the community has access to a great number of habitats that support a great variety of invertebrates. Interviews showed that invertebrate collection mainly serves home consumption needs and therefore does not target one particular species or habitat but usually a combination of several. Reeftop gleaning and diving for giant clams and 'other' species attract most male fishers; most females glean a combination of reeftop and intertidal habitats and may also dive for certain species. Almost all females target soft benthos and mangroves or mangroves alone, while about one-third of all male fishers collect in mangrove areas.

Table 5.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Chubikopi

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef & lagoon	47.1	85.0
	lagoon	20.6	15.0
	Lagoon & outer reef	29.4	0.0
	Outer reef	32.4	0.0
	Outer reef & passage	11.8	0.0
Invertebrates	Reeftop	0.0	14.8
	Reeftop & other	44.4	25.9
	Intertidal & reeftop	5.6	37.0
	Intertidal & reeftop & other	0.0	14.8
	Soft benthos & mangrove	11.1	59.3
	Mangrove	33.3	37.0
	Mangrove & other	5.6	0.0
	Lobster & other	5.6	3.7
	Other	44.4	3.7

'Other' refers to giant clams, lobsters and slipper lobsters fisheries.
Finfish fisher interviews, males: n = 34; females: n = 20. Invertebrate fisher interviews, males: n = 18; females: n = 27.

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip are the basic factors used to estimate the fishing pressure imposed by people from Chubikopi on their fishing grounds (Tables 5.2 and 5.3).

Our survey sample suggests that fishers from Chubikopi have a good choice among sheltered coastal reef, lagoon and outer reef fishing, including access to passages. As already mentioned, the same is true for invertebrate collection as the community has access to intertidal, soft-benthos, reeftop, lagoon and mangrove areas (Figure 5.6). The 'other' fishery, representing 22% of the invertebrate fishery, contains a mixture of species that males dive for, mostly associated with reef habitats, i.e. giant clams, lobsters and slipper lobsters. However, the category of 'others' may also contain other crustaceans, for example, crabs. Gender separation only shows in the fact that females do not particularly choose diving for invertebrates as an exclusive fishery. This category, labelled 'others' and representing mostly diving for giant clams and lobsters is a male fishers' domain. However, the female fishers of Chubikopi do dive but only in combination with gleaning and other techniques (Figure 5.7).

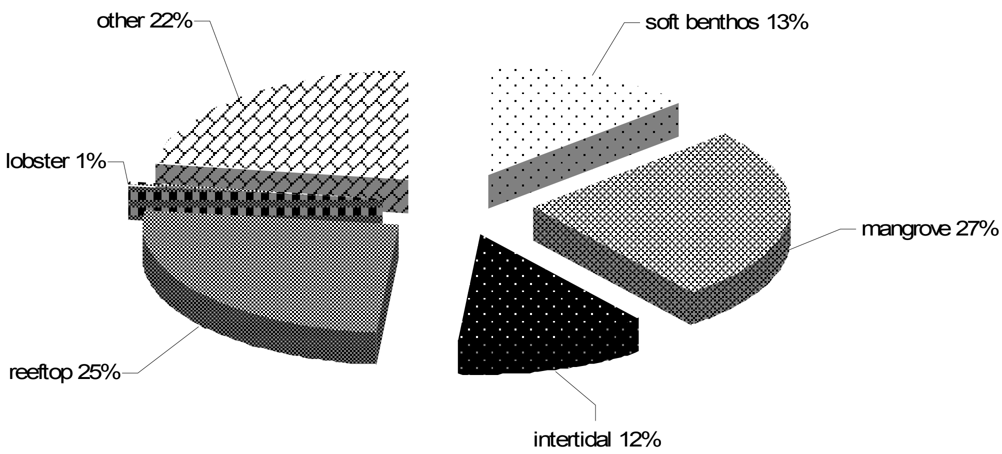

Figure 5.6: Proportion (%) of fishers targeting the six primary invertebrate habitats found in Chubikopi.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to giant clams, lobsters and slipper lobsters fisheries.

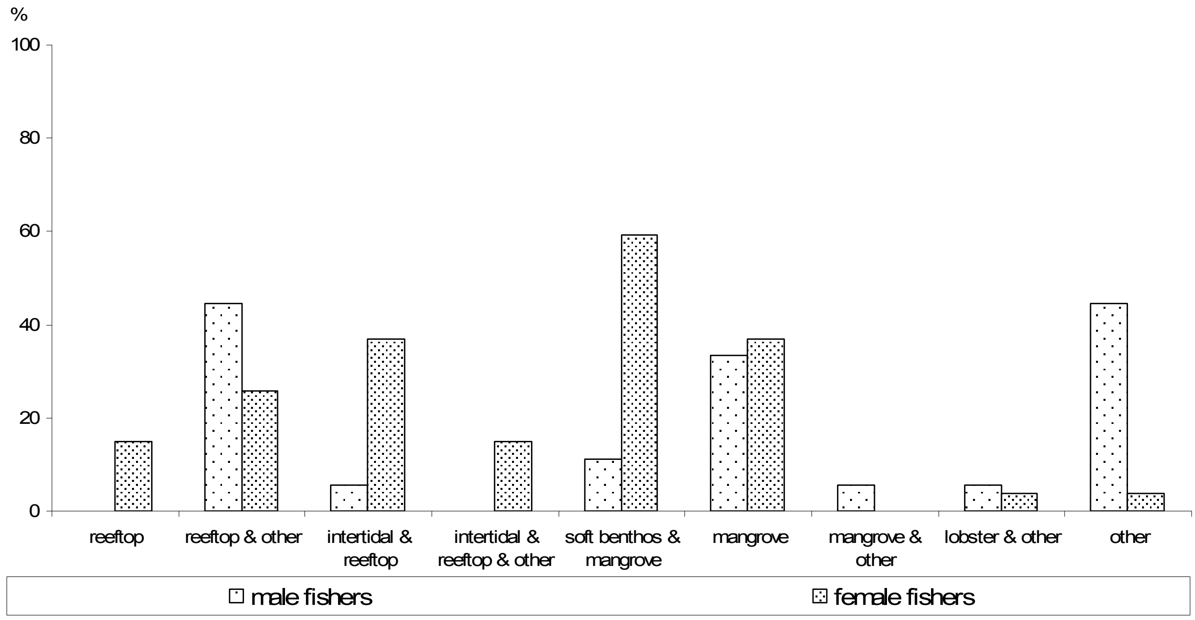

Figure 5.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Chubikopi.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 18 for males, n = 27 for females; 'other' refers to giant clams, lobsters and slipper lobsters fisheries.

Gear

Figure 5.8 shows that Chubikopi fishers use a variety of different fishing gear, that they may combine different fishing techniques if catching fish in a particular habitat, and that low-cost fishing equipment is mostly used. When fishing closer to shore, i.e. the combined fishing of sheltered coastal reef and lagoon areas, handlines and castnets are used. Lagoon fishing, also when combined with outer-reef fishing during the same fishing trip still mainly uses handlines, castnets, spear diving, deep-bottom lining and handheld spearing, alone or in combination. Gillnets are not commonly used, but may be used in combination with handlines and spear diving in the areas close to shore. Outer-reef fishing mainly uses deep-bottom lining in combination with spear diving, handlining or trolling, and some diving with mask and snorkel, including the use of dropping stones (Figure 5.8).

The Chubikopi community is also very influenced by its church, and traditional group fishing activities are organised to supply food for religious or traditional events and obligations.

Invertebrate collection mostly uses very simple techniques, such as digging, collecting by hand or netting in tidal pools, seagrass beds and sand and mud flats, as well as in mangroves, using sticks, knives and other available tools.

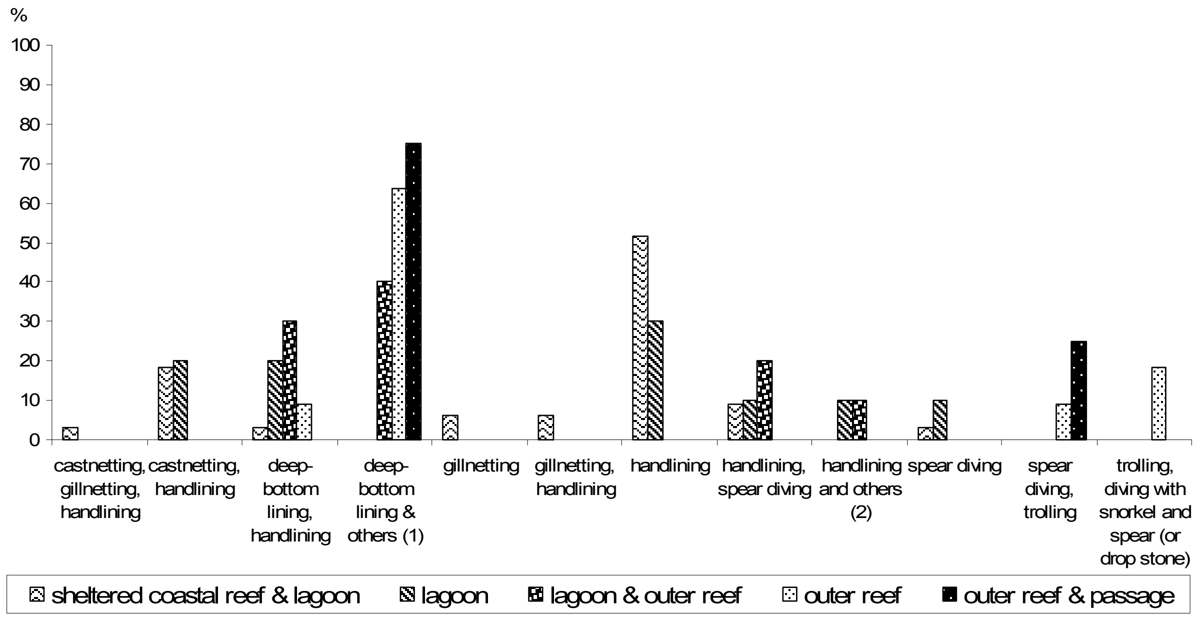

Figure 5.8: Fishing methods commonly used in different habitat types in Chubikopi.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.
(1) Spear diving and/or handlining and/or trolling; (2) spear diving and/or trolling and/or tow lining.

Frequency and duration of fishing trips

Male and female finfish fishers go out to any of the finfish habitats about 2 times/week. As shown in Table 5.3, the fact that an average fishing trip targeting the outer reef and passages takes longer (4–5 hours) may explain why female fishers fish the habitats closer to shore. Here, there is no marked difference between genders; both spend on average 3–4 hours per fishing trip.

Concerning invertebrate harvesting, the frequency of fishing trips is less as compared to finfish fishing. Both male and female fishers harvest invertebrates about once a week. Certain invertebrate fisheries are not very frequently performed though; for instance, male fishers rarely participate in intertidal and reeftop gleaning, and female fishers rarely participate in lobster and giant clam collection. On average, an invertebrate collection trip takes ~3–4 hours, similar to that of an average finfish fishing trip (Table 5.3).

The frequency and duration of fishing trips may also be determined by the use of boats. Canoes are almost always used for finfish fishing, and only on rare occasions do finfish fishers walk using handlines or castnets. The few motorised boats may be used for occasionally trolling and longlining at the outer reef; however, this mainly targets pelagic species. Most of the finfish fishing is done according to tidal conditions, although some finfish fishers, particularly females, prefer to catch fish only during the day. Finfish fishing is performed throughout the year and combined and interwoven with agricultural activities. The use of ice during fishing trips is not a standard practice; however, it was occasionally reported.

Most invertebrate collection is done using a canoe to reach the fishing ground or to support the diving and collection activities. Only intertidal collection may be done while walking and some fishers diving for certain species walk over the reef to begin. Usually, invertebrates are collected all year round with no particular season. All activities are exclusively performed during the day, and there are very few exceptions other than night diving for lobsters.

Both finfish fishing and invertebrate fishing activities are very limited due to the occurrence and threat of crocodiles.

Table 5.3: Average frequency and duration of fishing trips reported by male and female fishers in Chubikopi

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef & lagoon	1.88 (±0.13)	1.82 (±0.15)	3.25 (±0.19)	2.47 (±0.15)
	Lagoon	1.79 (±0.26)	2.17 (±0.17)	3.86 (±0.51)	3.33 (±0.33)
	Lagoon & outer reef	1.90 (±0.16)	0	4.30 (±0.21)	0
	Outer reef	1.60 (±0.26)	0	4.73 (±0.19)	0
	Outer reef & passage	1.63 (±0.24)	0	5.00 (±0.00)	0
Invertebrates	Reeftop	0	0.63 (±0.13)	0	3.00 (±0.00)
	Reeftop & other	0.93 (±0.07)	0.99 (±0.01)	3.25 (±0.16)	4.00 (±0.31)
	Intertidal & reeftop	0.23 (n/a)	1.18 (±0.19)	3.00 (n/a)	3.70 (±0.26)
	Intertidal & reeftop & other	0	0.92 (±0.08)	0	3.75 (±0.25)
	Soft benthos & mangrove	1.50 (±0.50)	0.93 (±0.15)	3.00 (±0.00)	4.81 (±0.16)
	Mangrove	0.87 (±0.09)	0.78 (±0.08)	3.17 (±0.31)	3.80 (±0.39)
	Mangrove & other	0.23 (n/a)	0	5.00 (n/a)	0
	Lobster & other	1.00 (n/a)	0.23 (n/a)	4.00 (n/a)	4.00 (n/a)
	Other	1.00 (±0.24)	1.00 (n/a)	3.38 (±0.18)	2.00 (n/a)

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to giant clam, lobster and slipper lobster fisheries.
Finfish fisher interviews, males: n = 23; females: n = 20. Invertebrate fisher interviews, males: n = 18; females: n = 27.

5.2.3 Catch composition and volume – finfish: Chubikopi

The catches reported from the sheltered coastal reef and lagoon fishing in Chubikopi contained numerous species and species groups. Scaridae, Lutjanidae, *Plectorhinchus* sp. and *Epinephelus fuscoguttatus* were the most dominant species or families reported. While vernacular name identification did not allow us to distinguish between Scaridae species, Lutjanidae included *Lutjanus bohar*, *L. adetii, L. russellii*, *L. sebae* and *L. fulvus*. Lethrinidae included *Monotaxis grandoculis*, *Lethrinus olivaceus* and *L. miniatus*. Other important families included Serranidae, Balistidae, Holocentridae and Carangidae. Catches reported from the outer reef and the combined fishing of outer reef and passages did not substantially vary from those referring to mainly lagoon fishing. However, Serranidae and Carangidae represented a much larger share of the total reported catch and, in general, the reported species diversity was much less. Balistidae and Holocentridae did not play an important role. Detailed information on catch composition by species, species groups and habitats are reported in Appendix 2.4.1.

Figure 5.9 highlights findings from the socioeconomic survey reported earlier, that finfish fishing serves mainly subsistence and much less commercial interests. The total annual catch is estimated to amount to ~223 t, of which ~75% is used for subsistence needs, while only ~25% is sold, either to logging companies or to visiting agents and middlemen. While participation in finfish fisheries did not vary much between gender groups, male fishers account for 78% of the total catch; female fishers contribute ~22%. As reported earlier, the preference of female fishers to stay closer to shore also shows in the accumulated impact of both gender groups, i.e. ~60% of the total impact is imposed on sheltered coastal reef and lagoon habitats. The remaining ~40% of the catch is partly from the lagoon (combined lagoon and outer reef fish accounts for 20% of the total reported catch), but a substantial amount also comes from the outer reef and passages.

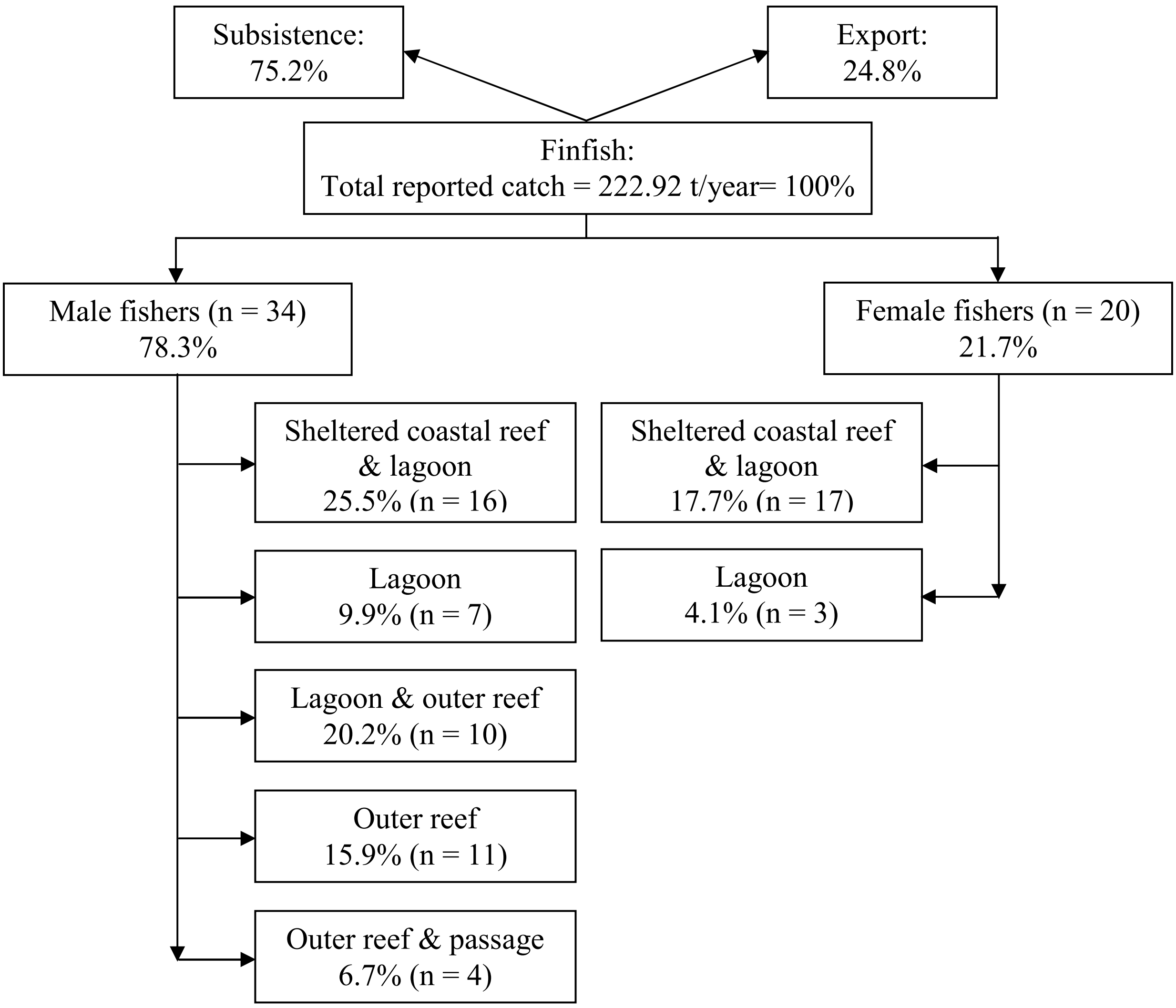

Figure 5.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Chubikopi.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The distribution of annual catch weight between the more easily accessible sheltered coastal reef and lagoon and the more distant outer reef and passages, is a consequence of the number of fishers rather than differences in the annual catch rates. As shown in Figure 5.10, the average annual catch per fisher is comparative between the combined fishing of sheltered coastal reef and lagoon, and of lagoon and outer reef habitats. Only the combination of lagoon and outer reef seems to render a higher average annual yield per fisher. However, on average it seems that a Chubikopi fisher may catch 300–400 kg/year, which is consistent with the high fish consumption, the average size of the households, and the low proportion of catch sold externally. Female fishers seem to harvest as much as males when targeting the lagoon, but much less if they combine sheltered coastal reef and lagoon areas.

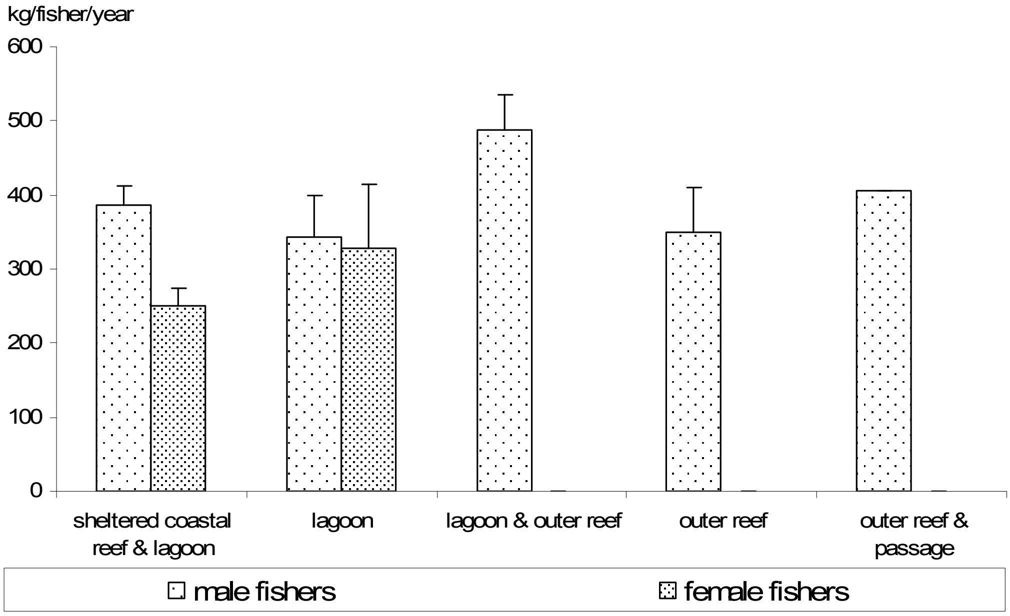

Figure 5.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Chubikopi (based on reported catch only).

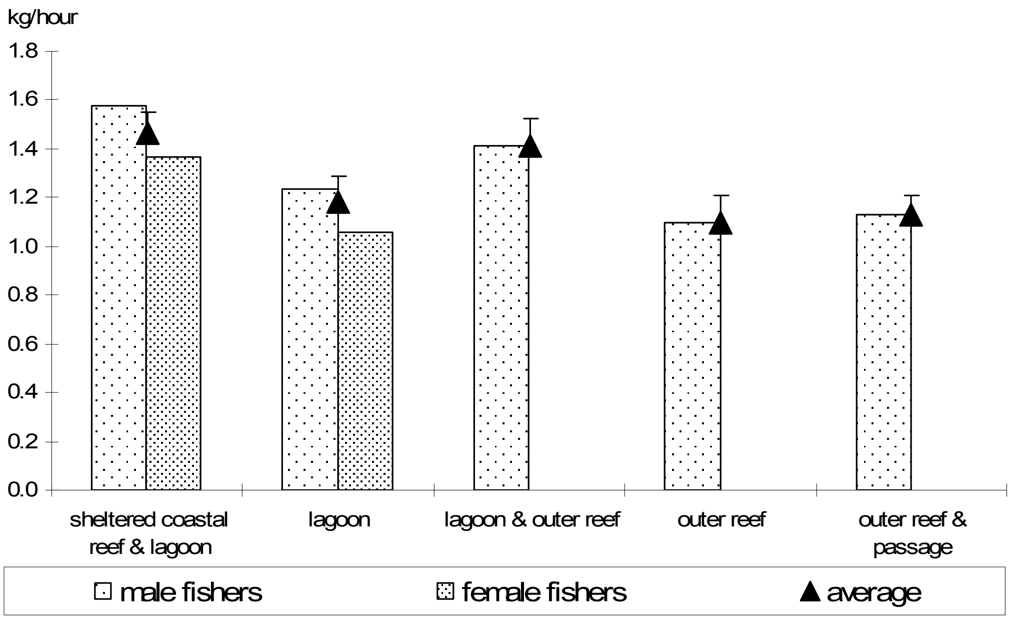

Figure 5.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Chubikopi.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

Comparing productivity rates (CPUE) between genders and among habitats (Figure 5.11), there are no obvious differences between male and female fishers. However, overall, CPUEs are low and hardly exceed 1.5 kg/hour of fishing trip. This result may suggest two things: firstly, as subsistence catch is the main objective for Chubikopi fishers, and non-motorised canoes and low-cost fishing gear are mainly used, fishers may not intend to maximise output while minimising their time investment, which results in generally low CPUEs. Secondly, the low CPUEs may also suggest that resource status is low.

The higher importance of subsistence than commercial fishing for Chubikopi's people clearly shows in Figure 5.12. As observed earlier, male fishers targeting the outer reef and passages (first fishing in the lagoon to catch some bait) fish more for income-generating purposes. The fishing of the sheltered coastal reef and lagoon, which is performed by most fishers in Chubikopi, is almost exclusively done to provide food for the family and the community. Because female fishers only target the sheltered coastal reef and lagoon, it can also be concluded that their participation in commercial finfish fishing activities is very low.

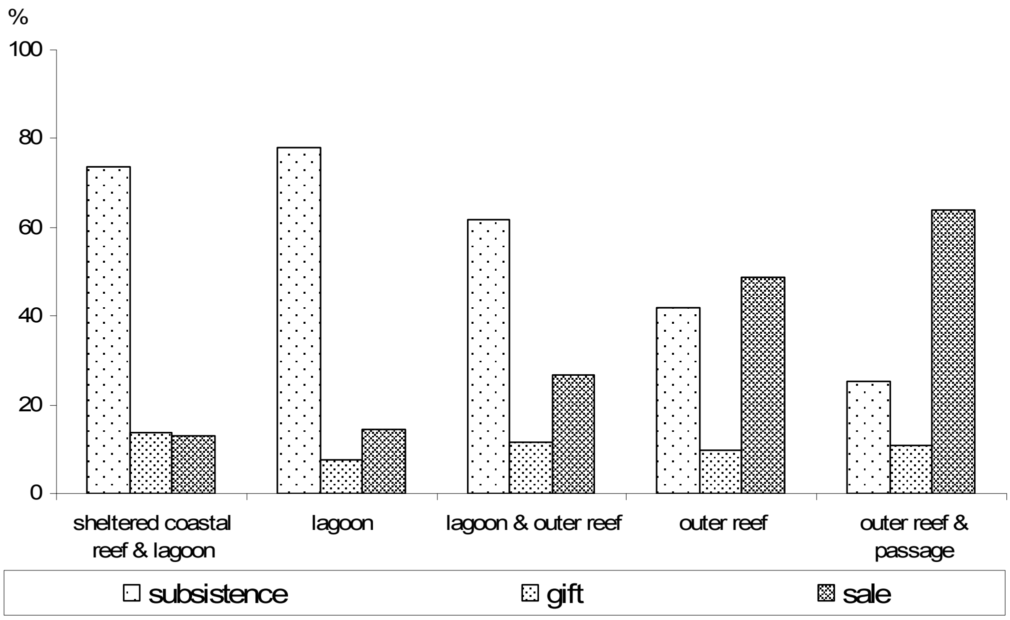

Figure 5.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Chubikopi. Proportions are expressed in % of the total number of trips per habitat.

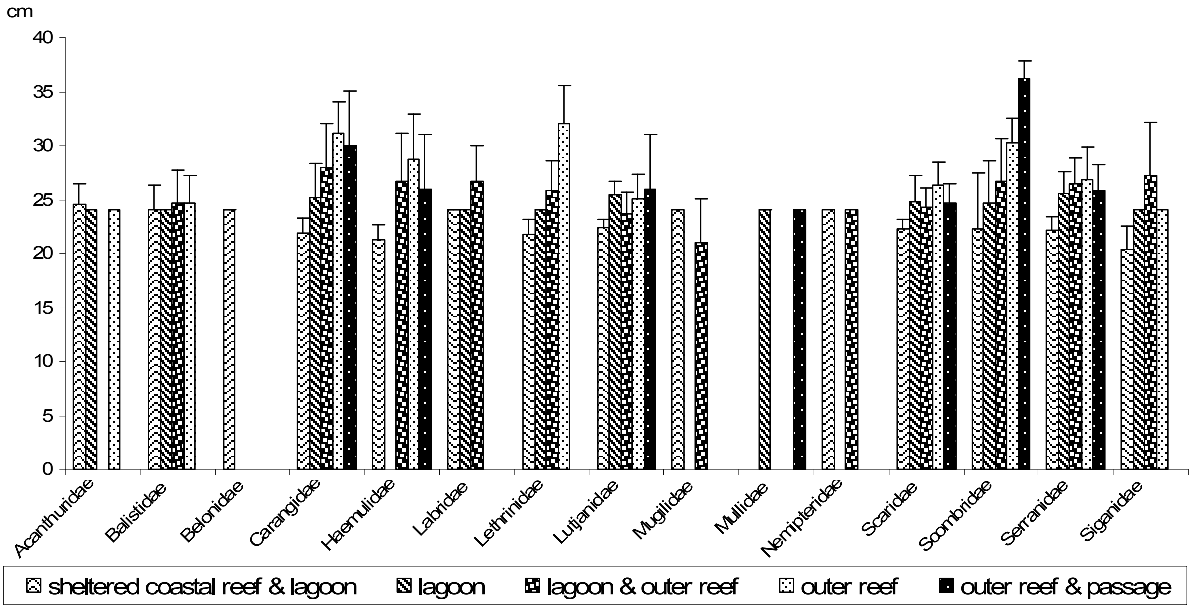

Figure 5.13: Average sizes (cm fork length) of fish caught by family and habitat in Chubikopi. Bars represent standard error (+SE); others (1) including: Sphyraenidae, Holocentridae, Carcharhinidae, Dasyatidae, Diodontidae, and Hemiramphidae are excluded as individual entries from graph for the sake of legibility; each of these families occurs in one of the habitats only.

The overall finfish fishing productivity per habitats suggests that efficiency (CPUE) is slightly higher in the areas closer to shore rather than at the outer reef and passages (Figure 5.11). This observation does not apply if comparing the reported average fish sizes for the major families caught (Figure 5.13). While certain families show no significant differences in average length when caught in different habitats (Acanthuridae, Balistidae and Scaridae), the classic and expected increase in average fish length from shore to the outer reef applies for most others, including Carangidae, Lethrinidae, Lutjanidae and Scombridae. These observations support the earlier suggestion, that fishing strategies rather than resource status may be the reason for the low CPUEs. Overall, the average reported fish length is about 25–30 cm.

The selection of indicators to assess current fishing pressure on Chubikopi reef and lagoon resources is shown in Table 5.4. Because the fishers distinguish between a sheltered coastal reef and lagoon habitat, although geomorphological classification does not account for the existence of a sheltered coastal reef, may explain why all the fishing pressure parameters skyrocket if considering the total reef area only. If taking into account the total available fishing ground, fishing pressure indicators decrease, and a low-to-moderate fisher density (12 fishers/km²), a moderate population density (32 people/km²) and a total fishing pressure of 3.2 t/year/km² for subsistence purposes (= 75% of the total annual catch) result.

Table 5.4: Parameters used in assessing fishing pressure on finfish resources in Chubikopi

Parameters	Habitat					
	Sheltered coastal reef & lagoon (4)	Lagoon	Outer reef (5)	Outer reef & passage (5)	Total reef area	Total fishing ground
Fishing ground area (km^2)	53.52	53.18	2.09	2.09	2.44	53.52
Density of fishers (number of fishers/km^2 fishing ground) (1)	7	2	44	16	266	12
Population density (people/km^2) (2)					706.6	32.3
Average annual finfish catch (kg/fisher/year) (3)	316.39 (±20.84)	338.91 (±43.72)	350.28 (±60.23)	404.90 (±71.62)		
Total fishing pressure of subsistence catches (t/km^2)					70.0	3.2
Total number of fishers	348	96	91	33	650	650

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1727; total subsistence demand = 171.03 t/year; (3) catch figures are based on recorded data from survey respondents only; (4) lagoon & 0.3412 km² sheltered coastal reef; (5) outer reef area includes passages; lagoon & outer reef with 83 fishers, average annual catch/fisher = 487.84 kg (±47.10) not included in the above table for the sake of legibility.

5.2.4 Catch composition and volume – invertebrates: Chubikopi

Calculating catches reported from invertebrate fishers shows that only a few species account for the major annual impact expressed in wet weight (Figure 5.14). The combined catches of giant clams (including *Tridacna derasa*, *Hippopus hippopus* and *T.* spp.), *Scylla serrata* and *Parribacus antarcticus* alone account for 16.8 t/year or 68% of the total annual reported catch. Other important target species are *Strombus* spp., *Birgus latro*, *Cardisoma* spp., *Panulirus* spp. and *Terebralia palustris*. All other species, including trochus, rock oysters and other bivalves and gastropods make no significant contribution in terms of wet weight.

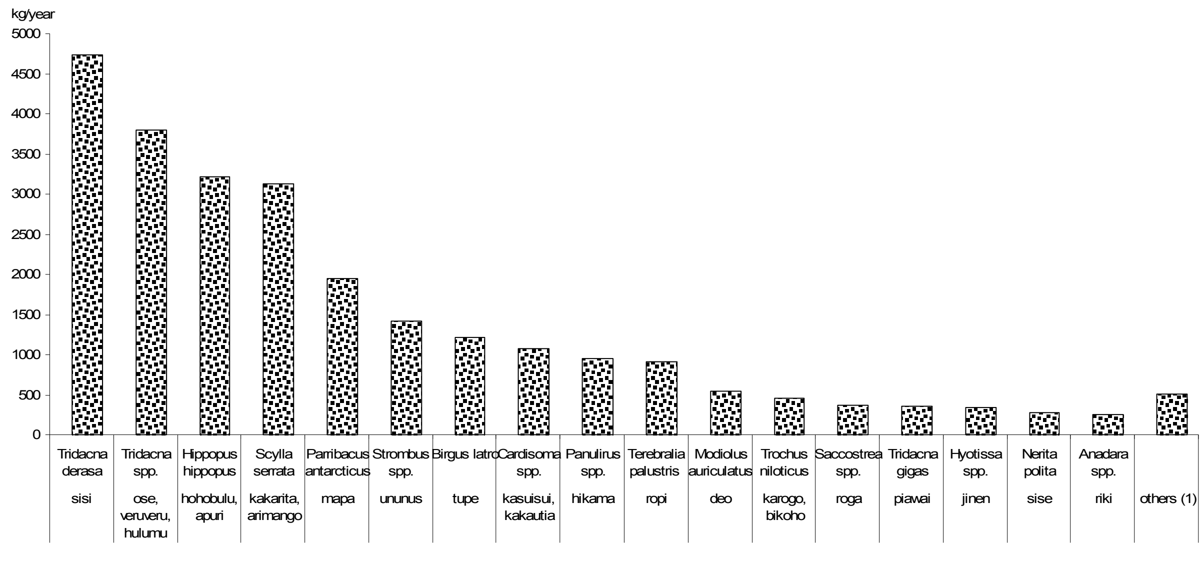

Figure 5.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Chubikopi.
Others (1) include: *Tridacna maxima* (*chavi*, *ghuhum*), *Lambis scorpius* (*ronga*), *Acanthopleura* sp. (*livogivisi*), *Octopus* spp. (*sipiu*) (all <300 kg/year).

The fact that most impact is imposed on only a few species also shows in the number of vernacular names that have been registered from respondents. Reeftop gleaning and diving for mostly reef-associated species is represented by the highest number of vernacular names

(10), while mangrove fishing focuses on two species only. However, Figure 5.15 again highlights that Chubikopi fishers usually combine a number of different habitats in one gleaning trip (Figure 5.15).

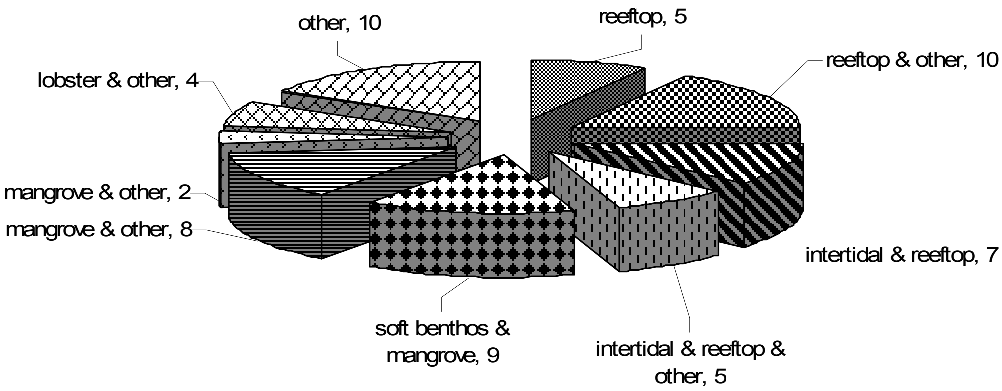

Figure 5.15: Number of vernacular names recorded for each invertebrate fishery in Chubikopi.
'Other' refers to the giant clam, lobster and slipper lobster fisheries.

The average annual catch per fisher by gender and fishery (Figure 5.16) reveals substantial differences among fisheries. While male and female fishers seem to harvest about the same amount per year (wet weight) if targeting the same fisheries, the combined harvesting of reeftops by gleaning and diving for reef-associated species renders by far the highest average annual catch (~600 kg/fisher/year wet weight). All other fisheries provide comparatively low average annual catches, for example, ~300 kg/fisher/year (wet weight) in the case of intertidal, reeftop and other gleaning, soft benthos and mangrove harvesting as well as mangrove harvesting alone. These results suggest firstly that invertebrate fishing in Chubikopi mainly serves subsistence needs; secondly, it is best represented by a set of species that occur across the reeftop and wider lagoon area and, to some extent, by mangrove resources.

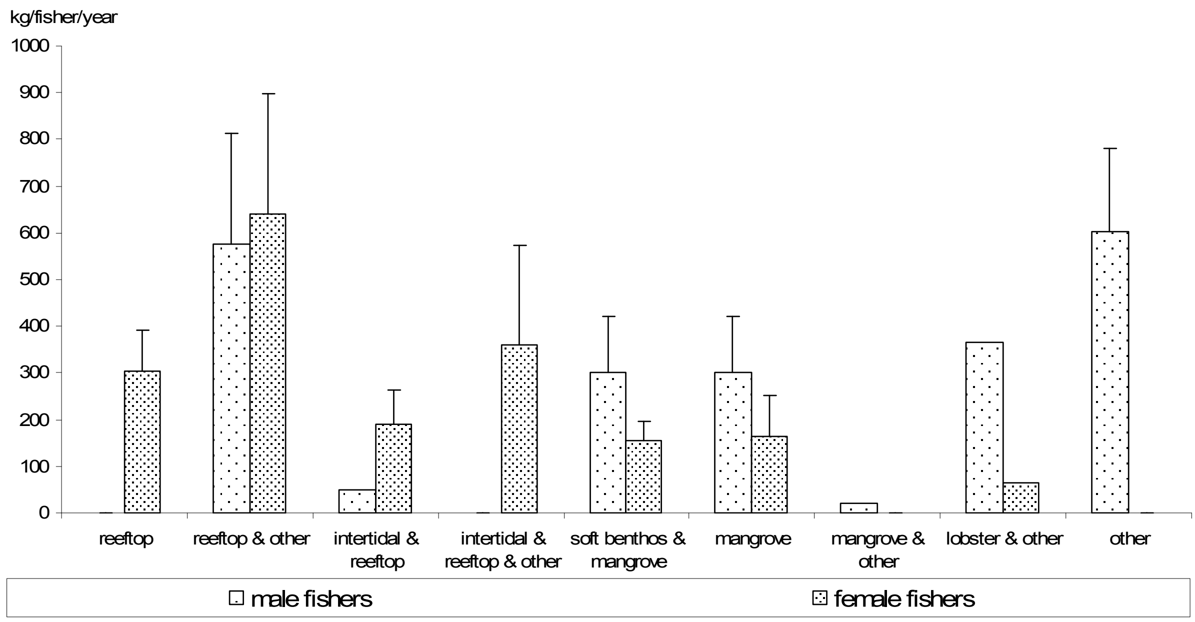

Figure 5.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Chubikopi.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 17 for males, n = 29 for females); 'other' refers to the giant clam, lobster and slipper lobster fisheries.

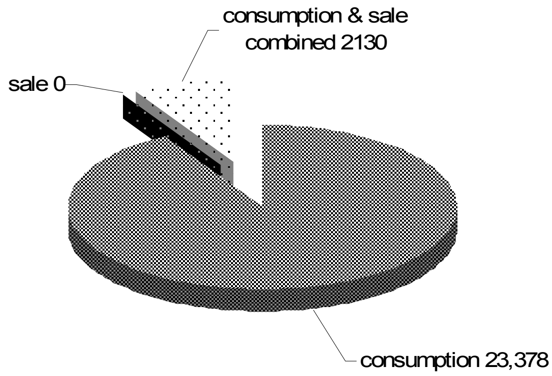

Figure 5.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Chubikopi.

The above observation that invertebrate collection mainly serves subsistence needs in Chubikopi is confirmed by results shown in Figure 5.17. The proportion that is sold on the local markets may not exceed 4% of the total annual reported catch or 1065 kg/year if we assume that half of the share that may be consumed or sold, is indeed sold. There is no record for a species or a catch that is exclusively collected for sale. Species that are targeted for sale or for religious and traditional obligations include giant clams, lobsters and the green mangrove crab.

As mentioned earlier, male fishers from Chubikopi are involved in invertebrate fisheries as much as females. This shows in the balanced proportion of total annual catch accounted for (~48% by male fishers and ~52% by female fishers, Figure 5.18). Most of Chubikopi male invertebrate fishers target the reeftop by gleaning and diving for giant clams ('other'), and this shows in the highest proportion of total annual catches (wet weight). Female fishers add another ~23% of total annual reported catch of reeftop resources. As shown by average annual catches and numbers of fishers, mangroves and soft-benthos resources are subject to the second-highest annual impact by wet weight (~25% of total annual catches). The impact on lobster resources is negligible by comparison (1.7% of total annual reported catch by wet weight).

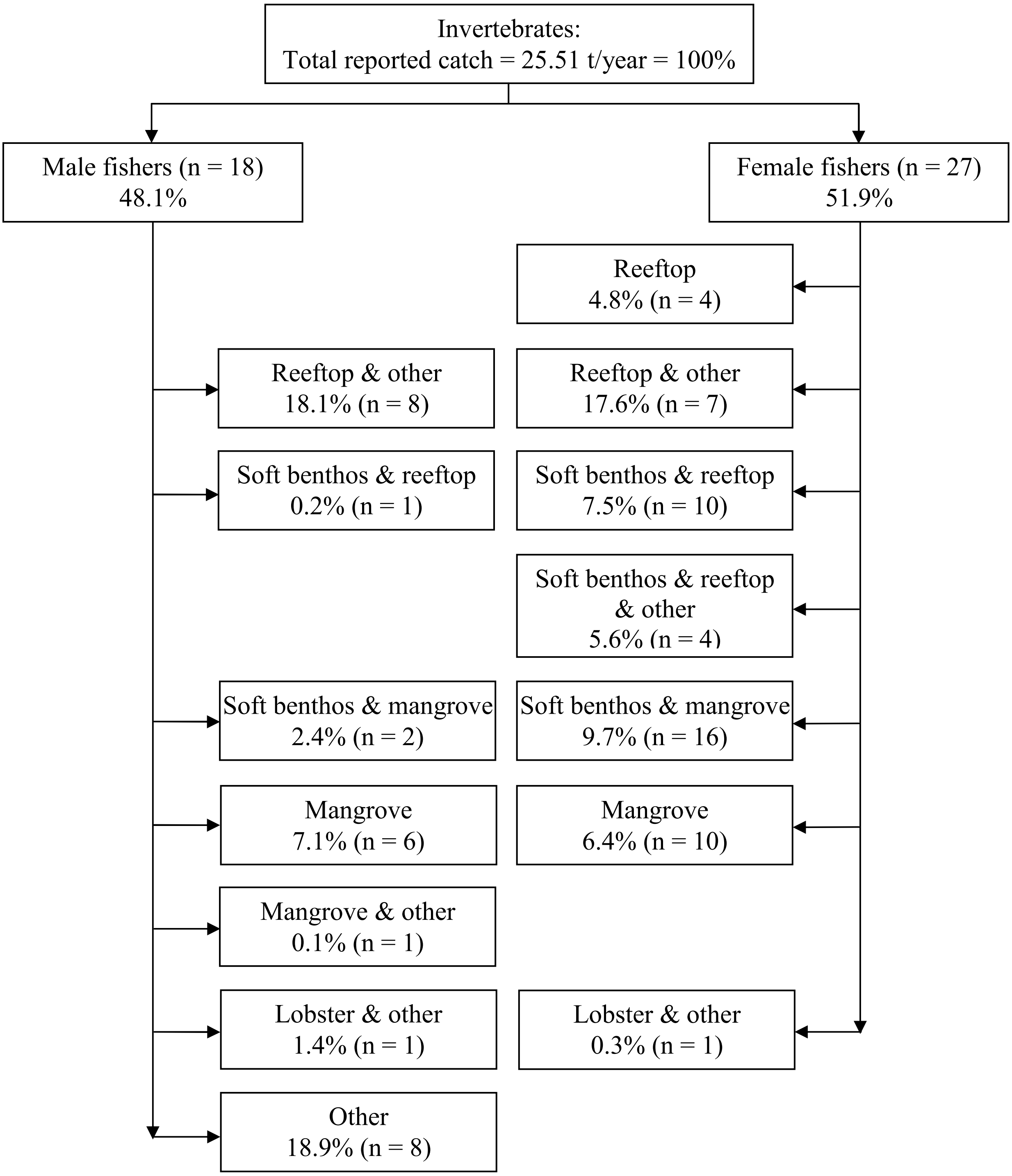

Figure 5.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Chubikopi.
n is the total number of interviews conducted per each fishery; n/a = no information available; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; 'other' refers to the giant clam, lobster and slipper lobster fisheries.

Table 5.5: Parameters used in assessing fishing pressure on invertebrate resources in Chubikopi

Parameters	Fishery / Habitat								
	Reeftop	Reeftop & other	Intertidal & reeftop	Intertidal & reeftop & other	Soft benthos & mangrove	Mangrove	Mangrove & other	Lobster & other	Other
Fishing ground area (km^2)	1.41					n/a		11.77 [3]	1.64
Number of fishers (per fishery) [1]	42	159	116	42	190	169	11	21	85
Density of fishers (number of fishers/km^2 fishing ground)	29.9							1.8	
Average annual invertebrate catch (kg/fisher/year) [2]	304.00 (±86.44)	606.55 (±167.32)	177.86 (±67.21)	358.87 (±212.88)	171.07 (±39.15)	215.61 (±69.83)	19.74 (n/a)	215.32 (±150.35)	602.86 (±179.25)

Figures in brackets denote standard error; 'other' refers to the giant clam, lobster and slipper lobster fisheries; [1] total number of fishers is extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] outer reef linear measurement (km).

Taking into account figures available on the surface areas available for fishing, the reeftop is, as expected, subjected to a moderate-to-high fisher density. There is a great number of fishers, both males and females, targeting the reeftop alone and in combination with other habitats. Surface areas for soft benthos and mangroves are difficult to determine. Thus, it can only be speculated that most of the fishing pressure is in fact imposed on the community's accessible reef resources and, to some extent, mangrove and soft-benthos species. Considering that giant clams are among the most targeted species, negative impacts may already show, as these bivalves are subject to long recuperation periods. The extensive outer-reef length that is considered to support the lobster dive fishery, coupled with the small number of fishers who harvest lobsters, results in a low fishing pressure for lobster fishing alone (Table 5.5). However, before final assessment is made, these findings need to be compared and considered together with results from the resource surveys.

5.2.5 Management issues: Chubikopi

Chubikopi, as most other rural coastal communities in Solomon Islands, is governed by traditional social institutions, including land and marine tenure. This system allows for *tabu* and totems that can help in managing land and marine resources. As long as resources are available, social cohesion maintains compliance with such regulations. Because Chubikopi is an isolated rural area with little access to urban markets and cash-generating opportunities, the predominant use of traditional and low-cost fishing techniques supports low-level fishing strategies. The use of canoes rather than motorised boats limits the choice and accessibility of fishing grounds. The fear of crocodiles makes night fishing almost impossible and limits catches from mangrove habitats. Muddy areas and other habitats that support crocodiles have increased since logging operations have started around the Marovo lagoon. However, although fishing strategies may be inefficient, the high population density and high dependency on marine resources for food can also cause total fishing impact to exceed the sustainable level for the available and accessible resources. Past experiences have shown that the bêche-de-mer, aquarium-trade and trochus fisheries, which offered attractive income opportunities, have been overexploited and as a result have declined. While bêche-de-mer and aquarium-trade fishing (mainly live corals) are now, at least temporarily, banned, trochus is still one of the commercial target species. The current low catches and low participation of fishers in this fishery suggests that not much of the resource is left, although people are desperate to earn cash income.

Activities supported by the IWP from SPREP have resulted in the establishment and continuation of a community-managed marine protected area in the waters of Chea. The Morovo lagoon offers a vast fishing area with a variety of different habitats. Considering the valuable traditional knowledge of the people concerning lunar, tidal and seasonal conditions, more marine protected areas should be established and more effort made to manage fisheries using a community-management approach.

5.2.6 Discussion and conclusions: socioeconomics in Chubikopi

The Chubikopi community is an isolated, rural coastal area determined by traditional and religious institutions. People have access to agricultural land and marine resources. However, due to its distance from major markets: Gizo in Western Province and Honiara in Guadalcanal, commercialisation of fisheries produce is limited to the fortnightly visits of middlemen and agents who control prices and keep them low. The former bêche-de-mer and aquarium-trade (live corals) income opportunities no longer exist due to (temporary) bans.

Trochus, a fishery that is still open, does not produce attractive catches, which suggests that the status of this resource is low. It is therefore not surprising that most finfish and invertebrates are caught to satisfy local food and protein needs, and seafood consumption figures are high. Wood carving represents the major source of income for the people.

Although traditional *tabu* and totems are part of the local lifestyle, more awareness is needed of the need to reduce fishing pressure (not only on selected species) and to also manage the finfish fishery. First efforts undertaken by the IWP from SPREP have resulted in alerting the Chea community and establishing a community-managed marine protected area.

In summary, survey results suggest the following:

- Chubikopi's population is highly dependent on its marine resources for home consumption, but only to a small degree for income generation. The distance to the urban markets of Gizo and Honiara, lack of ice and preservation facilities, and low prices for fisheries produce, all hinder any regular and larger-scale marketing of catch.

- Consumption of fresh fish is high (109.5 kg/person/year) and that of invertebrates (~9 kg/person/year) moderate. Both figures are similar to the average across all four sites surveyed in Solomon Islands. However, canned fish consumption (4.5 kg/person/year) is slightly below average and explained by the low household expenditure level.

- There are no strong gender roles in fisheries. However, male fishers fish more the fishing grounds further from shore, such as the outer reef and passages, as they use the few motorised boats available to the community. Males also dive exclusively for certain invertebrate species, while females only dive occasionally if the situation demands during their gleaning trips.

- Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community mostly uses non-motorised canoes.

- Overall, CPUEs are low, ~1.5 kg fish/hour of fishing trip. Fishing at the outer reef is less productive than fishing inside the lagoon. CPUEs are not significantly different between male and female fishers fishing in the same habitats.

- A wide range of traditional and mostly low-cost fishing techniques is used, often in combination. Castnets and handlines are the main methods used in the sheltered coastal reef and lagoon. The use of gillnets and spear diving is not that popular. Outer-reef fishing often involves deep-bottom lining, trolling, and longlining but also handlining and the use of spears and drop stones. The average fish sizes reported are 25–30 cm. Most fish families show the expected increase in average fish size with distance from shore.

- Results from the invertebrate fisher survey show that catches of giant clams, the crab *Scylla serrata*, and lobsters account for most of the annual harvest (wet weight). By comparison, trochus catches are low.

- In contrast to finfish fishing, significant differences were found in average annual catches by invertebrate fishery. Catches reported for the combined gleaning of reeftops and diving for selected species were by far the highest, while all other fisheries have rather small catches.

Fishing pressure indicators calculated for finfish fisheries suggest that, due to the available reef and overall fishing ground area, fisher and population densities and subsistence catch per available surface unit area vary significantly. Due to the small reef surface and high population and consumption figures, fishing pressure indicators calculated per km² of reef area are extremely high. If the total fishing ground is taken into consideration, these indicators are considerably reduced and suggest moderate fishing pressure levels. Generally speaking, the current exploitation level of invertebrates for subsistence does not seem to be alarmingly high. However, considering that most of the catch is determined by giant clams and crustaceans, these species need to be monitored. Due to the past overharvesting of bêche-de-mer and aquarium-trade (live coral) resources, low resource status of other species can be assumed as well as these currently and temporarily banned species. Trochus catch data also suggest that the resource status is poor.

5.3 Finfish resource surveys: Chubikopi

Finfish resources and associated habitats were assessed between 9 and 16 December 2006, from a total of 24 transects (6 sheltered coastal, 6 intermediate-, 6 back- and 6 outer-reef transects; see Figure 5.19 and Appendix 3.4.1 for transect locations and coordinates respectively).

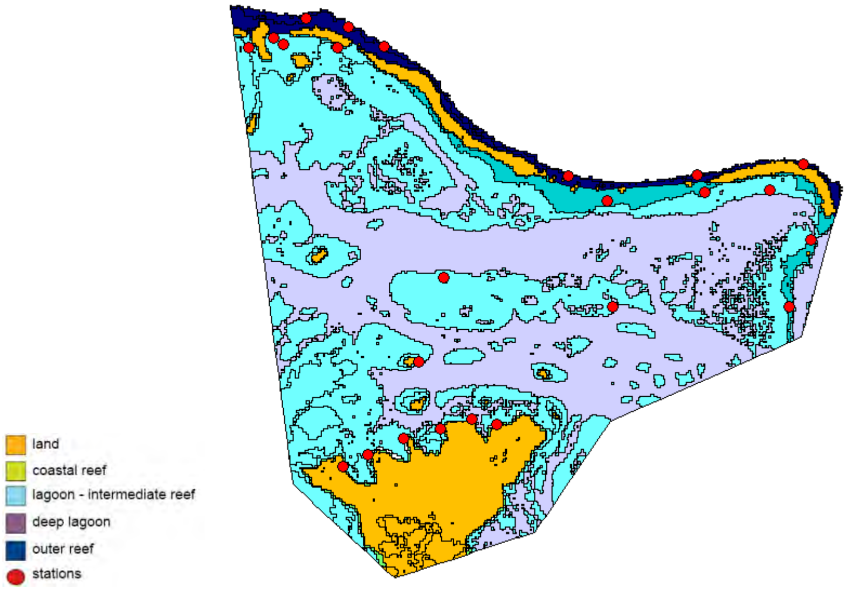

Figure 5.19: Habitat types and transect locations for finfish assessment in Chubikopi.

5.3.1 Finfish assessment results: Chubikopi

A total of 22 families, 59 genera, 202 species and 11,476 fish were recorded in the 24 transects (See Appendix 3.4.2 for list of species.). Only data on the 14 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 47 genera, 179 species and 6837 individuals.

Finfish resources varied greatly among the four reef environments found in Chubikopi (Table 5.6). The outer reef contained the greatest number of species (52 species/transect), highest number of fish (0.4 fish/m^2 – same as in the back-reef), largest average fish size (19 cm FL) and largest biomass (73 g/m^2). In contrast, the coastal reef displayed the lowest number of species (29 species/transect), density (0.3 fish/m^2) and biomass (41 g/m^2). The back-reef displayed the lowest average fish size (15 cm FL) and size ratio (50%). The intermediate reefs showed intermediate values of density (0.4 fish/m^2), size (16 cm FL) and biomass (44 g/m^2) between the coastal and back-reefs, but higher diversity (48 species/transect).

Table 5.6: Primary finfish habitat and resource parameters recorded in Chubikopi (average values ±SE)

Parameters	Habitat				
	Sheltered coastal reef (1)	Lagoon (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	0.3	25.8	2.1	2.1	30.4
Depth (m)	6 (3–1) (3)	5 (1–10) (3)	3 (1–6) (3)	6 (1–20) (3)	5 (1–20) (3)
Soft bottom (% cover)	29 ±7	26 ±11	27 ±6	3 ±1	25
Rubble & boulders (% cover)	8 ±1	7 ±1	7 ±2	3 ±1	6
Hard bottom (% cover)	35 ±7	32 ±10	39 ±9	41 ±9	33
Live coral (% cover)	25 ±7	31 ±12	22 ±6	48 ±7	31
Soft coral (% cover)	0 ±0	1 ±0	1 ±0	2 ±1	1
Biodiversity (species/transect)	29 ±5	48 ±4	37 ±3	52 ±6	41 ±3
Density (fish/m^2)	0.3 ±0.1	0.4 ±0.1	0.4 ±0.1	0.4 ±0.1	0.4
Size (cm FL) (4)	17 ±1	1 ±1	15 ±1	19 ±1	16
Size ratio (%)	56 ±3	59 ±2	50 ±2	56 ±3	58
Biomass (g/m^2)	41.1 ±15.1	44.0 ±5.5	50.1 ±13.8	72.9 ±19.2	46.4

(1) Unweighted average; (2) weighted average that takes into account relative proportion of habitat in the study area; (3) depth range; (4) FL = fork length.

Sheltered coastal reef environment: Chubikopi

The sheltered coastal reef environment of Chubikopi was dominated by two families of herbivorous fish: Acanthuridae and Scaridae, and two families of carnivorous fish: Chaetodontidae (16 species) and Holocentridae (Figure 5.20). The three commercial families were represented by 22 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Scarus rivulatus*, *Acanthurus nigricauda*, *Chlorurus bleekeri*, *Myripristis violacea* and *Neoniphon sammara* (Table 5.7). This reef environment presented a moderately diverse habitat with hard bottom (35%), soft bottom (29%) and live coral (25%) in similar proportions (Table 5.6 and Figure 5.20).

Table 5.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Chubikopi

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.06 ±0.01	8.7 ±1.7
	Acanthurus nigricauda	Epaulette surgeonfish	0.01 ±0.00	3.6 ±1.8
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.02 ±0.02	6.3 ±5.9
	Chlorurus bleekeri	Bleeker's parrotfish	0.01 ±0.01	3.1 ±2.7
Holocentridae	*Myripristis violacea*	Lattice soldierfish	0.01 ±0.01	1.2 ±1.2
	Neoniphon sammara	Blood-spot squirrelfish	0.01 ±0.01	0.5 ±0.5

The density, biomass and biodiversity of finfish in the sheltered coastal reefs of Chubikopi were the lowest values recorded among all reef habitats as well among all coastal reefs in the country. The trophic structure in Chubikopi coastal reefs was only slightly dominated by herbivorous species in density; however, biomass of carnivores was much lower than herbivores. Size ratios of Holocentridae, Labridae and Lethrinidae were much below the 50% limit, suggesting a strong exploitation of these target species.

The sheltered coastal reefs of Chubikopi displayed similar high percentage of hard and soft bottom and a relatively good proportion of corals. This constitution of the substrate may partially explain the fish community composition: herbivorous fish are in fact generally associated with hard bottom, while carnivorous species are generally associated with soft bottom.

Figure 5.20: Profile of finfish resources in the sheltered coastal reef environment of Chubikopi. Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Chubikopi

The intermediate-reef environment of Chubikopi was dominated by two herbivorous families: Acanthuridae and Scaridae (represented by 22 species), both in terms of density and biomass (Figure 5.21), and by Chaetodontidae (19 species); particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Scarus dimidiatus*, *Chlorurus bleekeri*, *S. rivulatus*, *Zebrasoma scopas* and *C. sordidus* (Table 5.8). This reef environment presented a moderately diverse habitat with hard bottom (32% cover), live coral (31%) and soft bottom (26%) in similar proportions (Table 5.6 and Figure 5.21).

Table 5.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Chubikopi

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.105 ±0.027	14.0 ±3.3
	Zebrasoma scopas	Twotone tang	0.016 ±0.007	0.9 ±0.5
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	0.038 ±0.029	1.9 ±0.8
	Scarus rivulatus	Rivulated parrotfish	0.008 ±0.008	1.1 ±1.1
	Chlorurus sordidus	Daisy parrotfish	0.008 ±0.003	0.7 ±0.2
	Chlorurus bleekeri	Bleeker's parrotfish	0.007 ±0.002	1.2 ±0.4

The density and biomass of fish in the intermediate reefs of Chubikopi were lower than in both back- and outer reef and slightly higher than in coastal reef. Species diversity was, however, good, lower only than the outer-reef value. Average fish size was intermediate between coastal- and back-reef values but size ratio was the highest among all reefs (59%). When compared to the other sites, Chubikopi intermediate reefs displayed the lowest values of density, size and biomass, but the second value of biodiversity (lower than in Marau) and the highest value of size ratio. Trophic structure was dominated by herbivores, in both density and biomass terms. However, size ratio was low for herbivores, especially Scaridae (43%) and Mullidae (40%), suggesting a high level of exploitation. The intermediate reef of Chubikopi had high and similar percentage cover of hard bottom, coral and soft bottom, which offer different substrates favourable to several species.

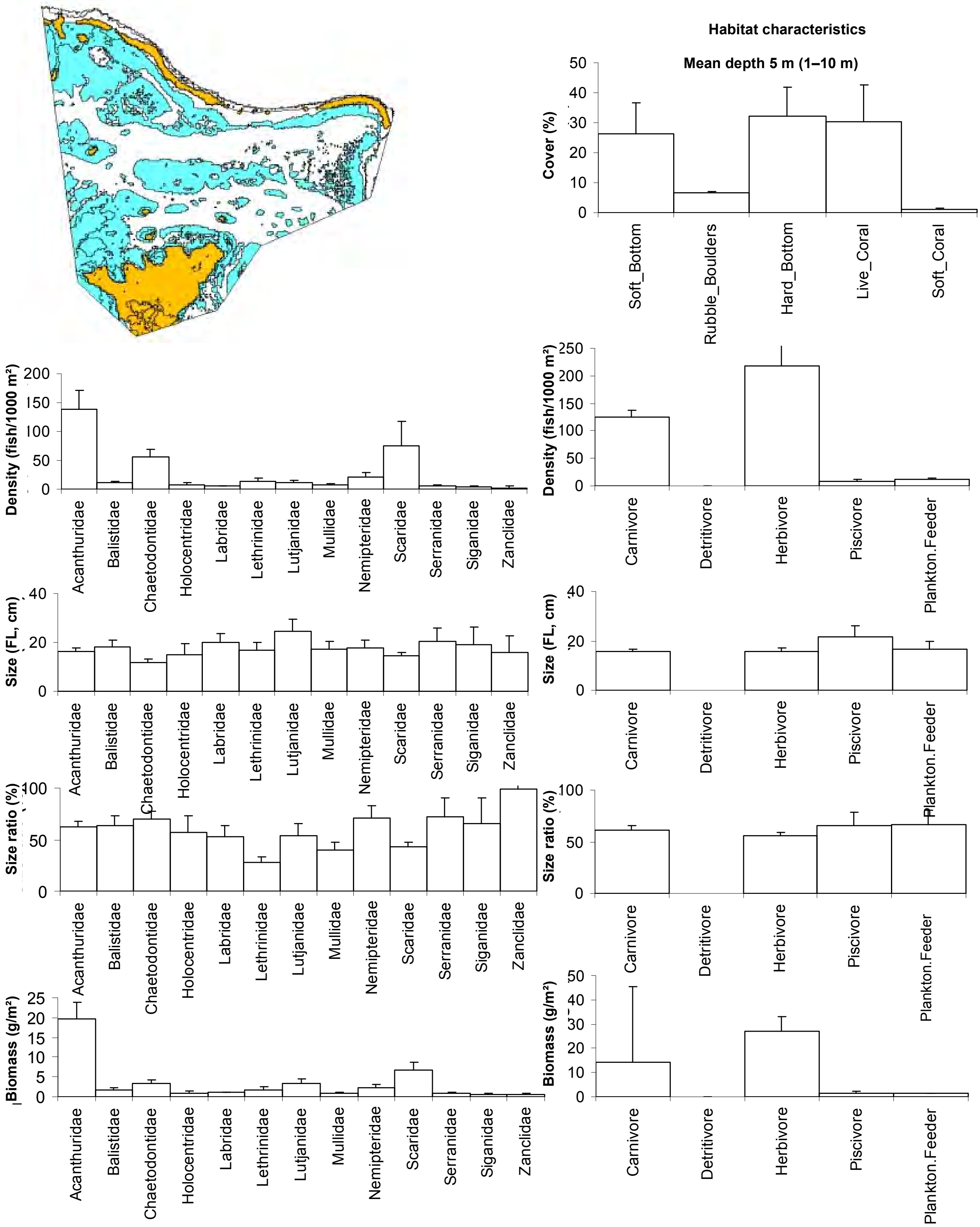

Figure 5.21: Profile of finfish resources in the intermediate-reef environment of Chubikopi. Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Chubikopi

The back-reef environment of Chubikopi was dominated by three families of herbivorous fish: Acanthuridae, Scaridae and Siganidae (Siganidae only in terms of biomass, Figure 5.22) and two families of carnivorous fish: Mullidae and Chaetodontidae (15 species). The four main families were represented by 24 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Siganus lineatus*, *Mulloidichthys flavolineatus*, *M. vanicolensis*, *Chlorurus bleekeri*, *Scarus psittacus* and *S. dimidiatus* (Table 5.9). This reef environment presented a moderately diverse habitat with hard bottom dominating (39% cover) over soft bottom (27%) (Table 5.6 and Figure 5.22).

Table 5.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Chubikopi

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Common parrotfish	0.07 ±0.007	1.5 ±0.7
	Scarus dimidiatus	Yellow-barred parrotfish	0.02 ±0.00	1.4 ±0.5
	Chlorurus bleekeri	Bleeker's parrotfish	0.01 ±0.01	1.7 ±1.0
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.07 ±0.02	11.5 ±3.0
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.02 ±0.02	3.7 ±3.7
	Mulloidichthys vanicolensis	Yellowfin goatfish	0.01 ±0.01	1.9 ±1.9
Siganidae	*Siganus lineatus*	Goldenlined rabbitfish	0.01 ±0.01	6.9 ±6.9

The density of finfish of the back-reefs of Chubikopi was comparable to the highest value, recorded in the outer reefs. However, biomass was lower than that in the outer reef and average size and size ratio were the smallest of the site (15 cm FL, 50%). Biodiversity was also low, with the second-lowest number of species after the coastal reefs. Compared to the other two sites presenting back-reefs, Chubikopi displayed the lowest values of all parameters, with biomass five times lower than in Marau back-reefs. The trophic structure in Chubikopi was only slightly dominated by herbivores in terms of both density and biomass. Piscivores and planktivores were practically absent. Holocentridae, Lethrinidae and Scaridae displayed very low size ratios, suggesting a very high level of exploitation. The back-reef of Chubikopi was represented by a high percentage of hard bottom, partially explaining the herbivore dominance, but also a good cover of soft bottom, favourable to some Lethrinidae (Abundant *Monotaxis grandoculis* were found here.). Live corals were relatively common (22% cover) but less than in the coastal reefs.

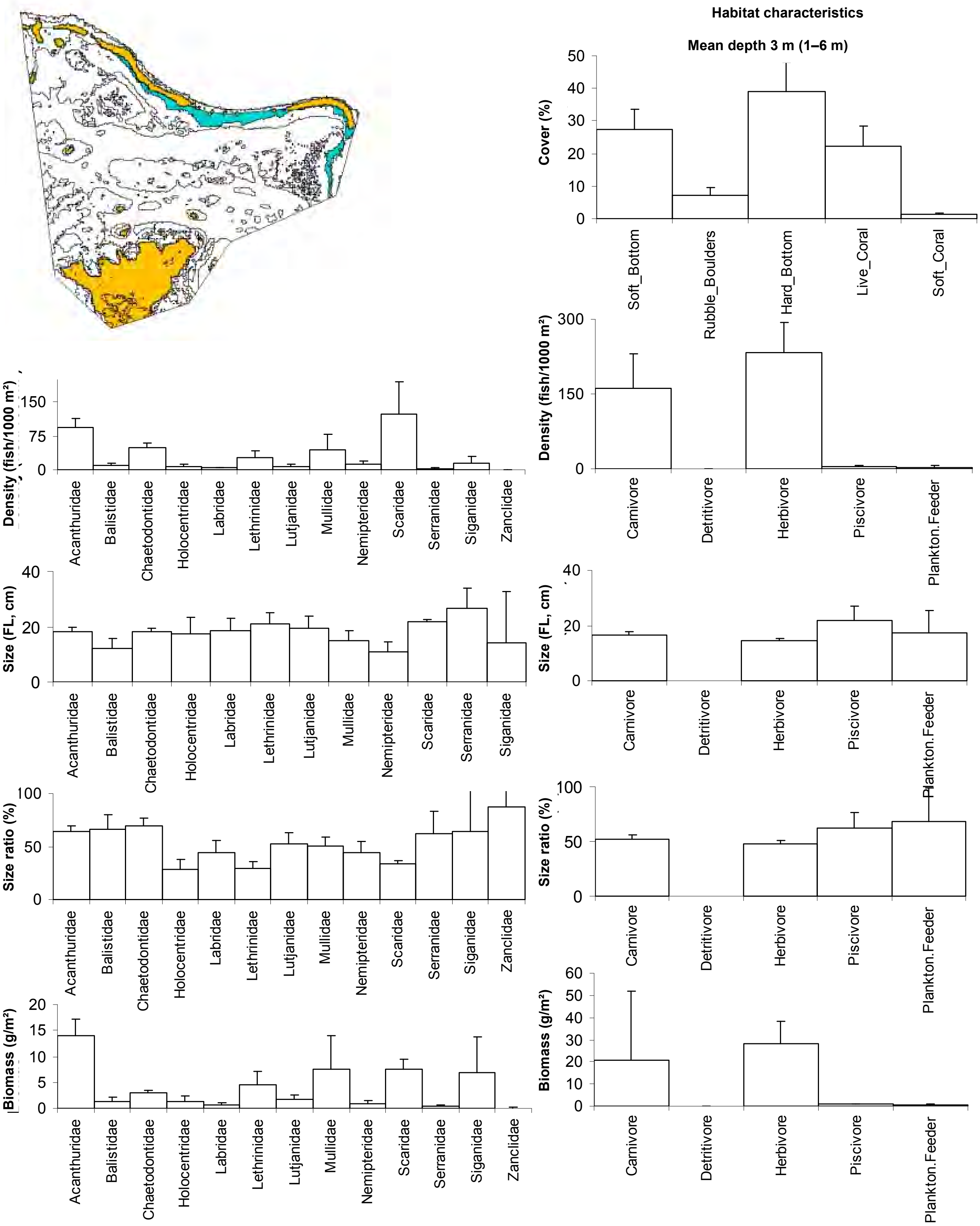

Figure 5.22: Profile of finfish resources in the back-reef environment of Chubikopi.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Chubikopi

The outer reef of Chubikopi was heavily dominated by herbivorous Acanthuridae and, to a much lesser extent, Scaridae (Figure 5.23). These two families were represented by 29 species; particularly high abundance and biomass were recorded for *Acanthurus lineatus*, *Hipposcarus longiceps*, *Ctenochaetus striatus*, *Naso lituratus* and *Scarus niger* (Table 5.10). Hard-bottom cover (41%) was high but the habitat was largely dominated by a high cover of live coral (48%, Table 5.6 and Figure 5.23).

Table 5.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Chubikopi

Family	Species	Common name	Density (fish/m^2)	Biomass (g/ m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.101 ±0.059	10.9 ±6.4
	Acanthurus lineatus	Lined surgeonfish	0.099 ±0.063	22.6 ±13.9
	Naso lituratus	Orangespine unicornfish	0.003 ±0.002	1.3 ±1.0
Scaridae	*Hipposcarus longiceps*	Pacific longnose parrotfish	0.034 ±0.003	12.1 ±11.8
	Scarus niger	Black parrotfish	0.006 ±0.003	1.2 ±0.4

The density, average size, biomass, and biodiversity of finfish in the outer reef of Chubikopi were higher than those recorded in the other reef habitats of the site (Table 5.6). Only size ratio was lower than in the intermediate reef (56% versus 59%). Among all outer reefs in the country, Chubikopi presented the lowest values of density, size ratio and biomass. However, biodiversity (52 species/transect) was lower only than the Rarumana value (60 species/transect). The fish community composition was highly dominated by herbivores (mainly Acanthuridae, highly abundant). The size ratios of Holocentridae, Lethrinidae and Scaridae were quite low, indicating a possible impact on such selected families. Substrate composition showed a strong dominance of live coral (48%) and hard bottom (41%). This outer reef was in fact very rich in corals, and characterised by a complex topography with shallow pools between the reef crest and the coast.

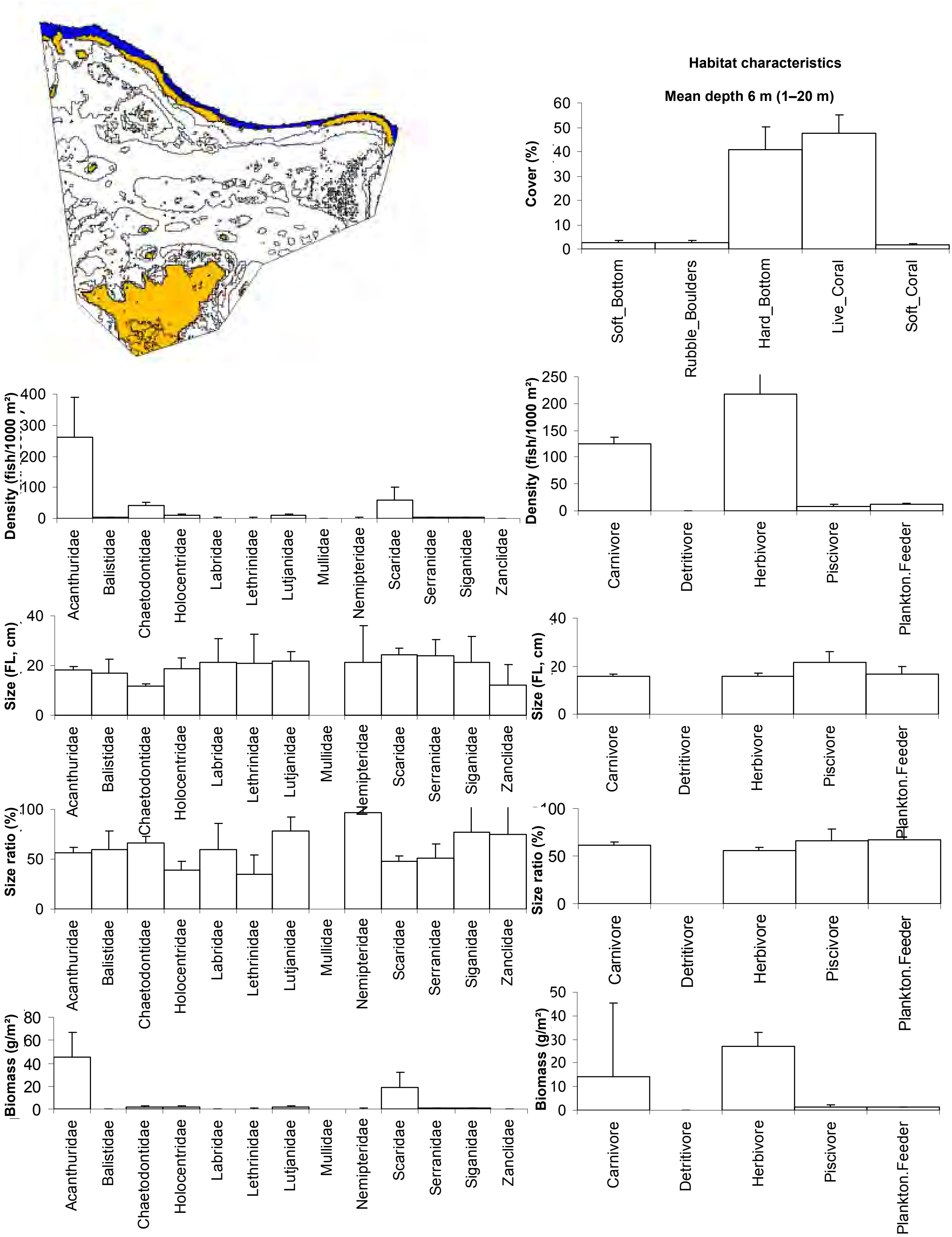

Figure 5.23: Profile of finfish resources in the outer-reef environment of Chubikopi.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Chubikopi

Overall, the fish assemblage of Chubikopi was dominated, in terms of density and biomass, by herbivores Acanthuridae and Scaridae. Chaetodontidae were relatively important in terms of density only (30 species, Figure 5.24). The two major families were represented by a total of 38 species, dominated by *Ctenochaetus striatus*, *Scarus dimidiatus*, *Acanthurus lineatus*, *Scarus rivulatus* and *Chlorurus bleekeri* (Table 5.11). Hard bottom (33% cover), live coral (31%) and soft bottom (25%) almost equally covered the substrate (Table 5.6 and Figure 5.24). The substrate, as well as fish community composition, mostly reflected the conditions of lagoon reef (85% of total reef area), and only to a small extent the coastal reef (7%), outer reef (7%) and back-reef (1%).

Table 5.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Chubikopi (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.102	13.6
	Acanthurus lineatus	Lined surgeonfish	0.009	2.5
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	0.034	1.7
	Scarus rivulatus	Rivulated parrotfish	0.007	1.0
	Chlorurus bleekeri	Bleeker's parrotfish	0.007	1.3

Overall, Chubikopi showed the lowest fish biodiversity among the four sites as well as the lowest density, size and biomass. The trophic structure was dominated by herbivores, which displayed a biomass more than twice as high as that of carnivores. The overall habitat composition offered niches for different fish families, but the general fish community was dominated essentially by Acanthuridae and Scaridae. Size ratios were very low for Lethrinidae, Mullidae and Scaridae, suggesting a high level of exploitation of these target groups.

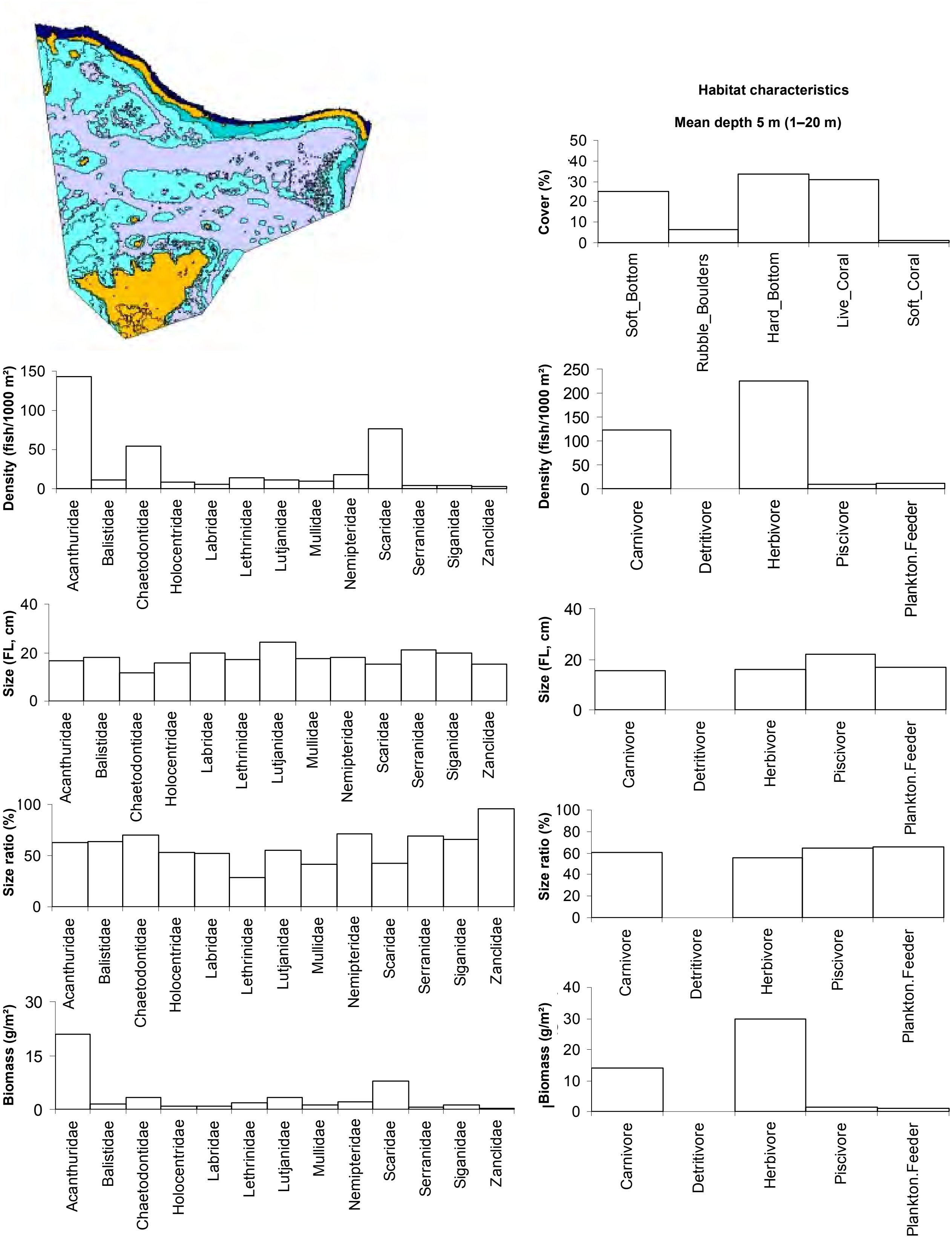

Figure 5.24: Profile of finfish resources in the combined reef habitats of Chubikopi (weighted average).
FL = fork length.

5.3.2 Discussion and conclusions: finfish resources in Chubikopi

The finfish resource assessment indicated that the status of finfish resources in Chubikopi is rather poor. Density, size and biomass values were consistently lower than at other sites. Coastal reefs appeared to be the poorest of all habitats and poorest compared to the coastal reefs of Marau and Rarumana; biomass was less than one-fifth of the biomass recorded in Marau. Only outer reefs displayed a biodiversity which was second-highest to biodiversity in the outer reefs in Rarumana, which was the highest at the site. Outer reefs in Chubikopi were rather complex, made of walls and outer lagoonal-type pools, hosting small and rare schools of *Bolbometopon muricatum*.

- Overall, Chubikopi finfish resources appeared to be in relatively poor condition. The reef habitat seemed relatively rich but the finfish community rather poor in both composition and abundance.
- The average sizes of target carnivores (Lethrinidae, Mullidae and Scaridae especially) were reduced; these reduced sizes, together with the lower numbers and biomass in all reefs were the first visible signs of fishing impact.
- The higher pressure put on back-reefs and coastal reefs is seen as overall smaller sizes of fish and very small density and biomass.
- The condition of Marovo lagoon seriously declined after heavy logging started as a major industry in the region. Complaints from local people and visitors were common concerning the condition of the water and the reefs inside the lagoon.

5.4 Invertebrate resource surveys: Chubikopi

The diversity and abundance of invertebrate species at Chubikopi were independently determined using a range of survey techniques (Table 5.12): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 5.25) and finer-scale assessment of specific reef and benthic habitats (Figures 5.26 and 5.27).

The main objective of the broad-scale assessment is to describe the distribution pattern of invertebrates (rareness/commonness, patchiness) at large scale and, importantly, to identify target areas for further, fine-scale assessment. Then, fine-scale assessment is conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 5.12: Number of stations and replicates completed at Chubikopi

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	20	120 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	4	24 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	7	42 search periods
Reef-front search by walking (RFs_w)	0	0 search period
Sea cucumber day searches (Ds)	4	24 search periods
Sea cucumber night searches (Ns)	2	12 search period

Figure 5.25: Broad-scale survey stations for invertebrates in Chubikopi.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 5.26: Fine-scale reef-benthos transect survey stations in Chubikopi.
Black circles: reef-benthos transect stations (RBt).

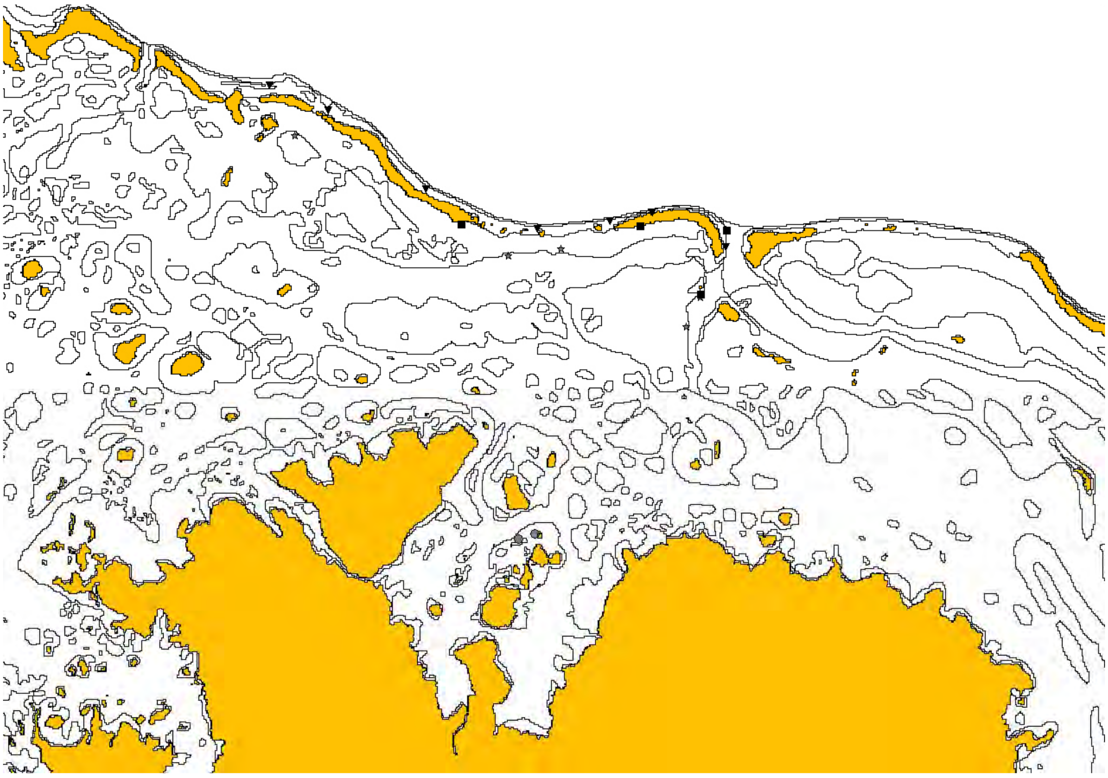

Figure 5.27: Fine-scale survey stations for invertebrates in Chubikopi.
Inverted black triangles: reef-front search stations (RFs);
black squares: mother-of-pearl transect stations (MOPt);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Sixty-five species or species groupings (groups of species within a genus) were recorded in the Chubikopi invertebrate surveys. These included 14 bivalves, 21 gastropods, 17 sea cucumbers, 5 urchins, 4 sea stars, 2 cnidarians and 1 lobster (Appendix 4.4.1). Information on key families and species is detailed below.

5.4.1 Giant clams: Chubikopi

The site at Chubikopi comprises a middle section of Morovo Lagoon from Vangunu and Morovo Island coast to the barrier reef (Lumalihe passage in the south and Charopoana Island near Uepi in the north). Although the lagoon was largely shallow and sandy, patch-reef habitat suitable for giant clams was recorded in small areas within the lagoon and on shoreline and the barrier reef (1.41 km^2 of lagoon reef and 1.64 km^2 of barrier reef and reef slope). This section of the lagoon (57.5 km^2) was predominantly influenced by land (allochthonous inputs and nutrients), although oceanic water was found around the barrier and passes. The system is mostly shallow and protected, with influence from land sources related to Vangunu and New Georgia Islands, which have been extensively logged in recent years (affecting sediment delivery into the lagoon). In general, the small patches of inshore reef and more extensive barrier reef provided a range of suitable environments for giant clams at Chubikopi.

Broad-scale sampling provided an overview of giant clam distribution throughout this section of Marovo lagoon. Reefs at Chubikopi held four species of giant clam: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the fluted clam *T. squamosa*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. The smooth clam, *T. derasa*, and the true giant clam *T. gigas* were not recorded in survey. Records from broad-scale sampling revealed that *T. crocea* had the widest occurrence (found in 9 stations and 30 transects), followed by *T. maxima* (2 stations and 4 transects). *T. squamosa* and *H. hippopus* were both recorded in 2 stations and 2 transects. The average station density of the most common species, *T. crocea*, in broad-scale surveys was low, at 32.0 clams/ha ±12.5; see Figure 5.28).

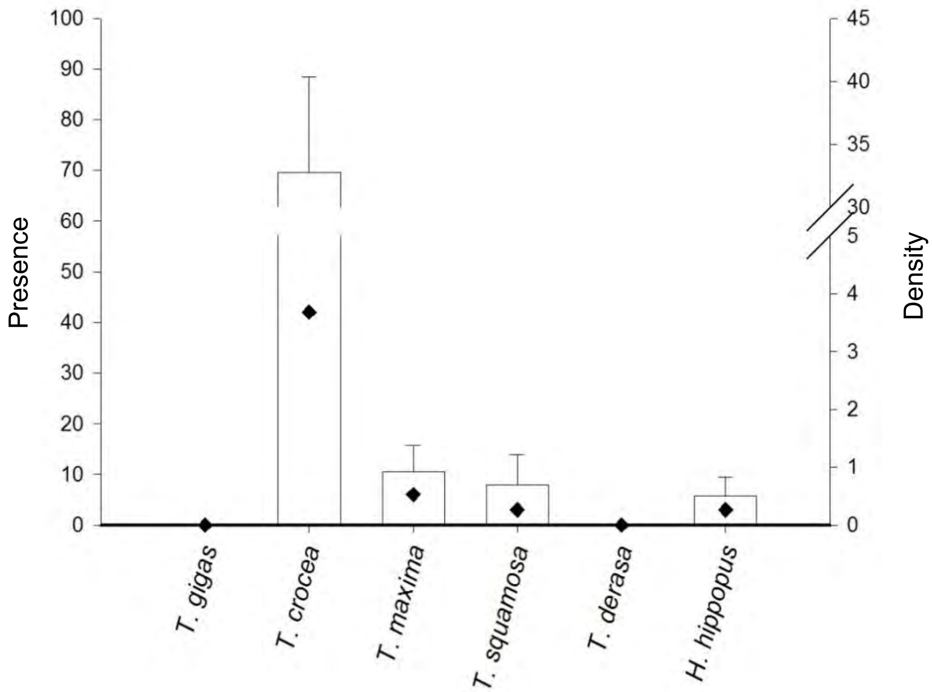

Figure 5.28: Presence and mean density of giant clam species at Chubikopi based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 5.29). In these reef-benthos assessments (RBt), *T. crocea* was present in 80% of stations, and was at the highest density of the clam species recorded (mean station density of 504.2 /ha ±129.2).

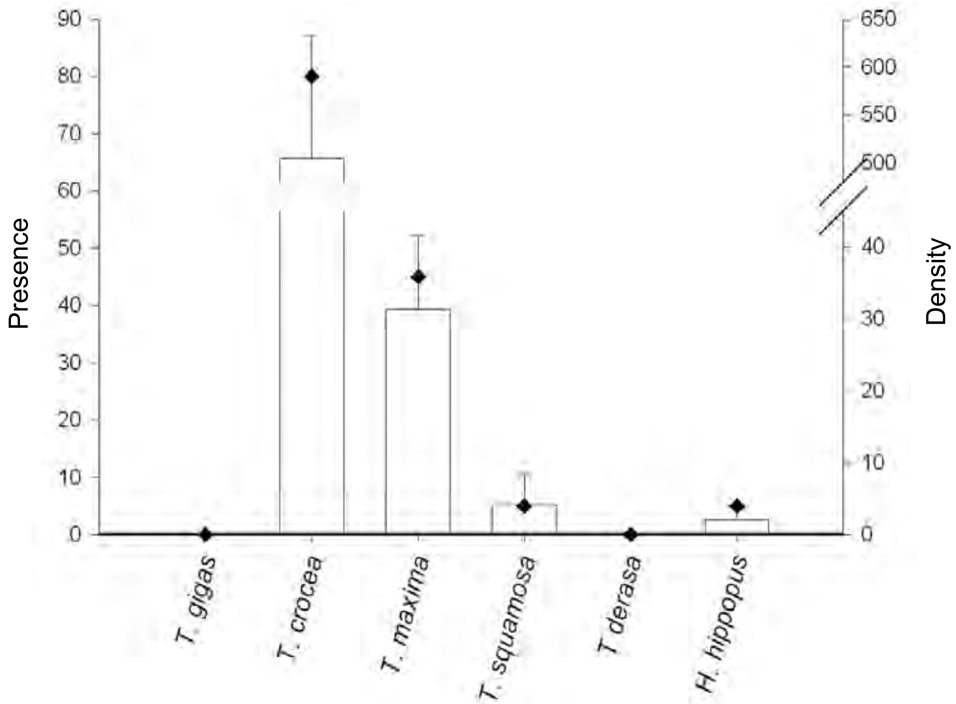

Figure 5.29: Presence and mean density of giant clam species at Chubikopi based on all reef-benthos transect assessments.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

The density of *T. crocea* was highest in RBt stations within the lagoon, especially on reefs just north of Marovo Island and near Lumalihe and Karikana passages (5 stations in these areas had a mean density of 1383.3 clams/ha ±116.7.). The highest *T. maxima* station density, outside Karikana passage, was 166.7, while 55% of RBt stations held no *T. maxima* at all.

From the 465 clam lengths recorded (from all assessment methods), the average shell length of giant clams was 7.7 cm ±0.2 for *T. crocea* (n = 410), 16.3 cm ±0.8 for *T. maxima* (n = 46), and 25.3 cm ±1.6 for *T. squamosa* (n = 6). Only three *H. hippopus* were measured (8, 20 and 25 cm).

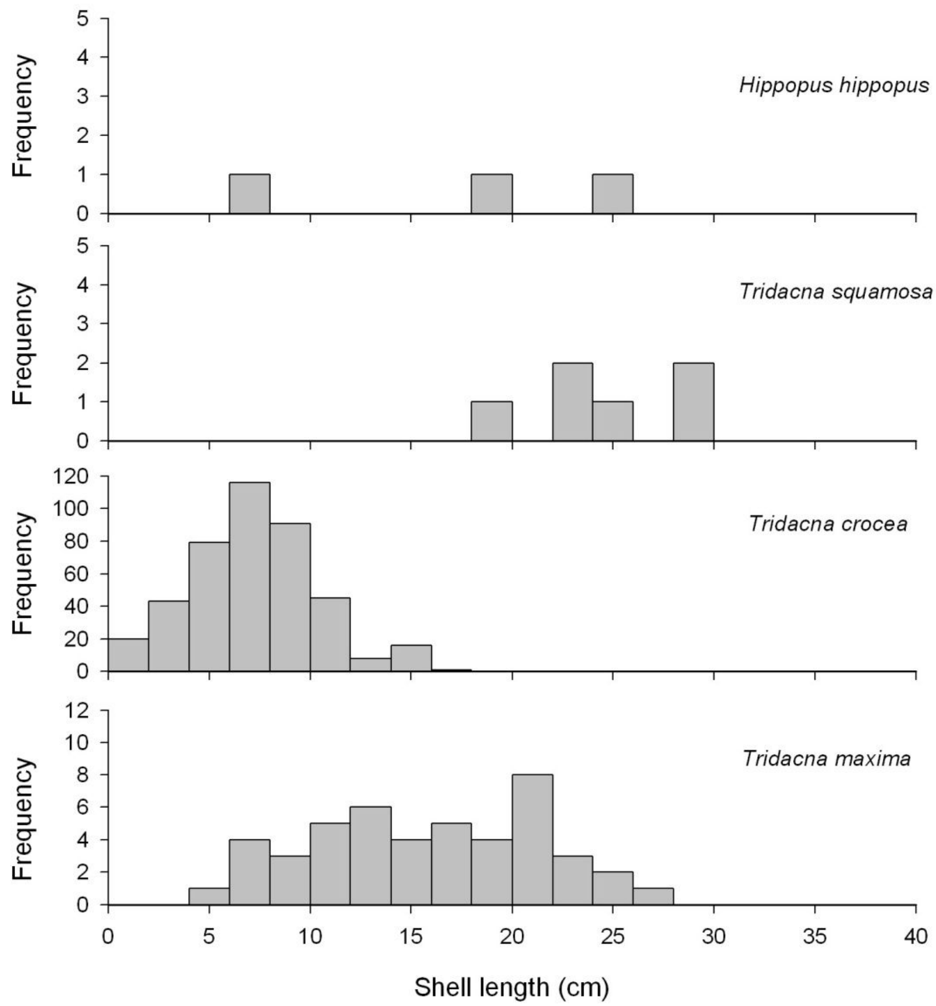

Figure 5.30: Size frequency histograms of giant clam shell length (cm) for Chubikopi.

5.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Chubikopi

The commercial topshell, *Trochus niloticus*, naturally occurs in Solomon Islands (natural distribution stops at Wallis Island to the east). The reefs at Chubikopi (11.5 km lineal distance of exposed reef perimeter) provide a moderate-sized area for adult *T. niloticus*, including some back-reef for juvenile habitat. However, this area was not all suitable, as much of the reef dropped steeply into deeper water, somewhat limiting available adult habitat. The exposed barrier-reef shoreline to the north of the lagoon was subject to dynamic water movement.

PROCFish/C survey work revealed that *T. niloticus* was located in reefs close to Morovo Island (well within the lagoon), as well as patch reef behind the Lumalihe passage and reef slope in front of the barrier (Table 5.13).

Table 5.13: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Chubikopi
Based on various assessment techniques; mean density measured in numbers/ha (±SE).

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	-	-	0/12 = 0	0/72 = 0
RBt	8.3	3.8	4/20 = 20	4/120 = 3
RFs	-	-	0/7 = 0	0/42 = 0
MOPt	5.2	5.2	1/4 = 25	1/24 = 4
Tectus pyramis				
B-S	-	-	0/12 = 0	0/72 = 0
RBt	143.8	67.6	10/20 = 50	29/120 = 24
RFs	11.2	6.2	4/7 = 57	14/42 = 33
MOPt	26.0	19.7	2/4 = 50	5/24 = 21
Pinctada margaritifera				
B-S	3.2	1.2	5/12 = 42	9/72 = 13
RBt	8.3	3.8	4/20 = 20	4/120 = 3
RFs	0.6	0.6	1/7 = 14	1/42 = 2
MOPt	88.5	45.3	3/4 = 75	11/24 = 46
Ds	3.6	2.3	2/5 = 40	3/30 = 10

B-S = broad-scale survey; RBt = reef-benthos transect; RFs = reef-front search; MOP = mother-of-pearl transect; Ds = day search.

As the trade winds originate from the southeast, the barrier reef to the north of Chubikopi is relatively protected and easily accessed for fishing. Much of these reefs is protected from the trade wind swell but not from equatorial monsoon conditions between December and March.

Despite the available habitat and wide-ranging presence of trochus, no high-density aggregations were noted, and survey stations held trochus at low density (a total of five individuals were recorded in all surveys). These broadcast spawners require males and females to be at close proximity (high density) to stimulate and facilitate reproduction.

Shell size also gives an important indication of the status of stocks, by highlighting the level of new recruitment into the fishery, which has implications for the numbers of trochus entering the capture size classes in the following two years. Young trochus enter the fishery stock at ~8 cm, when they are ~3 years old. Typically, trochus >11 cm are common in survey recordings, as these shells are less cryptic than smaller shells and, due to their prolific spawning potential, are protected from fishing so they can contribute to future harvests.

The mean size (basal width) of trochus at Chubikopi was 9.1 cm ±0.7 (n = 5; see Figure 5.31). No small trochus (<5 cm basal width) were recorded at Chubikopi. Despite this component of the stock generally being less visible among rubble and boulders, younger shells are normally picked up in surveys in small amounts, and more commonly from about 5.5 cm, when they emerge to join the main stock. As can be seen from the length frequency graph (Figure 5.31), young trochus were not recorded in Chubikopi, and large shells were also missing from sampling records despite shells larger than 12 cm basal length being protected from fishing in Solomon Islands (dotted line). In other fisheries in the region, trochus shells >11 cm make up 20% of the stock.

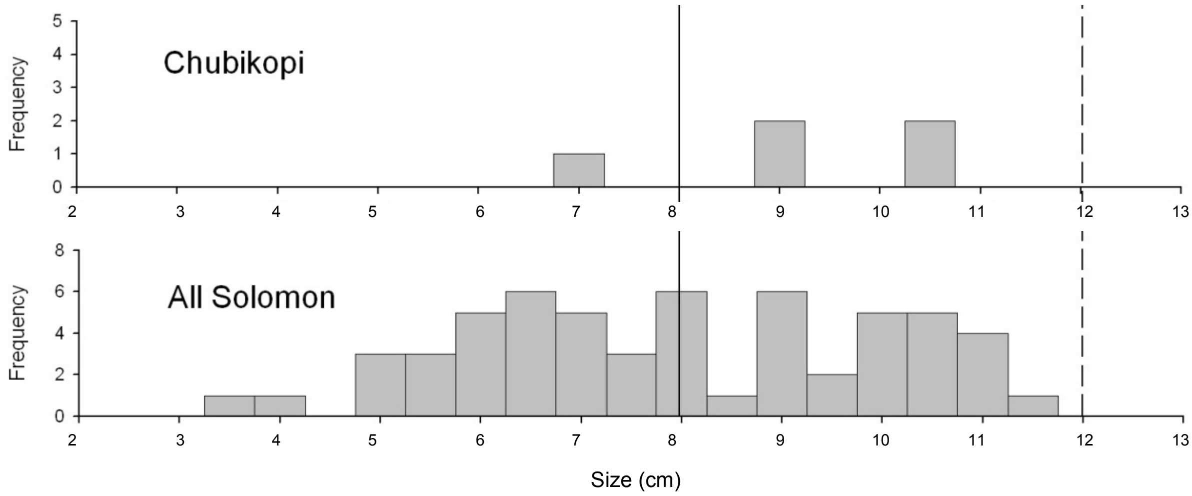

Figure 5.31: Size frequency histograms of trochus shell base diameter (cm) for Chubikopi.

It is obvious from these results that shells are not living to reach this size partly because the legal size classes are overfished and partly because trochus are being taken from the fishery even if they are over the legal size limit.

The suitability of reefs in this section of Marovo Lagoon for grazing gastropods was highlighted by results for the false trochus or green topshell (*Tectus pyramis*). This closely related species (with a similar life habit) was noted in seven times the number of shallow-water reef transects than trochus and at greater than 17 times the density. This less valuable species of algal-grazing topshell had a mean shell size of 5.7 cm ±0.1 (n = 92) and was recorded at moderately high density in some stations (>200 /ha in 4 of the 20 RBt stations).

The blacklip pearl oyster, *Pinctada margaritifera*, is generally a cryptic species, found from shallow to deep water (<1–50 m) sparsely distributed in open lagoon systems such as the one found at Chubikopi. However, blacklip were relatively common in surveys (n = 40), being recorded in many survey techniques (in 42% of broad-scale and 75% of SCUBA searches on the reef front where currents were greater). Blacklip pearl oysters noted in survey ranged in size from 9 to 20 cm (mean size 12.3 cm ±0.4, n = 36).

No greensnail, *Turbo marmoratus*, was recorded in survey.

5.4.3 Infaunal species and groups: Chubikopi

Soft-benthos areas were common along the coastal margins of Marovo Island although no areas of seagrass or in-ground resources (shell 'beds') were noted. Therefore, no fine-scale assessments or infaunal stations (quadrat surveys) were completed.

5.4.4 Other gastropods and bivalves: Chubikopi

Seba's spider conch, *Lambis truncata* (the larger of the common spider conchs), was absent in surveys, although *L. lambis* and the strawberry or red-lipped conch *Strombus luhuanus* were recorded in small numbers. *L. lambis* was noted in 33% of broad-scale and 10% of RBt stations, reaching an average density of just 6 /ha in the finer-scale surveys. *L. scorpius* and *L. chiragra* were also noted in surveys. Some relatively high-density patches of *S. luhuanus* were recorded in both B-S and RBt stations (Appendices 4.4.1 to 4.4.3).

Although the large *Turbo marmoratus* was not noted, *T. argyrostomus*, *T. chrysostomus*, and *T. setosus* were recorded in some assessments at low density. Nowhere were they common, and they were at less than 20 /ha in RBt stations. Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Latirolagena*, *Pleuroploca* and *Vasum*) were also recorded during independent surveys (Appendices 4.4.1 to 4.4.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa*, *Periglypta*, *Pinna*, *Pteria*, *Saccostrea* and *Spondylus*, are also in Appendices 4.4.1 to 4.4.7. No creel survey was conducted at Chubikopi.

5.4.5 Lobsters: Chubikopi

Chubikopi had 11.8 km (lineal distance) of exposed fringing reef. This exposed reef (and lagoon patch reef) provided a suitable habitat for lobsters. Lobsters are an unusual invertebrate species that can recruit from near and distant reefs as their larvae drift in the ocean for 6–12 months (up to 22 months) before settling as transparent miniature versions of the adult (pueruli, 20–30 mm in length).

There was no dedicated night reef-front assessment of lobsters (See Methods.) but, nevertheless, surveys still recorded eight *Panulirus* spp. No sand lobsters, banded prawn killer (*Lysiosquillina maculata*) or slipper lobsters were noted.

5.4.6 Sea cucumbers[14]: Chubikopi

As part of a major shallow-water lagoon system connected to extensive land masses (Marovo lagoon is over 70 km long; the study section was 57.5 km^2), the system at Chubikopi provided extensive areas of protected reef margins and mixed hard- and soft-benthos habitat that is suitable for sea cucumbers. There was significant land and riverine influence throughout the lagoon, with only the barrier reef and passage reef areas predominantly influenced by oceanic factors and dynamic water movement characteristic of New Georgia sound (‘The Slot’). The benthos throughout most of the lagoon was sandy, heavily epiphytic and depositional, with poor visibility predominating through much of the study. Around Chubikopi village itself the benthos was difficult to assess due to the presence of crocodiles and the wholly depositional, silty nature of the reef environments.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 5.14, Appendices 4.4.2 to 4.4.9; see also Methods). At Chubikopi, 17 commercial species of sea cucumber were recorded during in-water assessments, plus an unidentified, low-value species that is fished locally (*Holothuria* sp., known locally as ‘BS4’). The range of sea cucumber species recorded in Chubikopi was slightly lower than expected, considering the range and extensive coverage of suitable environments that were present, and the geographical position of Solomon Islands close to the centre of biodiversity.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*) were recorded in broad-scale survey, but at very low density. Leopardfish can sometimes be considered an indicator species for broad-scale assessments, as it is visible and

[14] There has been a recent variation to sea cucumber taxonomy which has changed the name of the black teatfish in the Pacific from *Holothuria (Microthele) nobilis* to *H. whitmaei*. There is also the possibility of a future change in the white teatfish name. This should be noted when comparing texts, as in this report the ‘original’ taxonomic names are used.

widespread across most lagoon sites. Distribution and average density records for this species when noted in shallow reef transect surveys or in reef-front searches indicated a highly impacted stock (<3 /ha), although more were seen when working on SCUBA (MOPt surveys recorded a mean density of 5.2 /ha.). Black teatfish (*Holothuria nobilis*), a high-value shallow-water species that is susceptible to overfishing, was completely absent from records. This species is another good indicator of fishing pressure and, as this species was absent from all surveys despite the availability of extensive areas of suitable environment, the assumption is that fishing pressure has decimated these stocks.

The fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was rare and at low density, only being recorded once in a single transect of 2.2 lineal km of broad-scale survey. Surf redfish (*Actinopyga mauritiana*), another easily targeted species that should be common on the outer-reef fronts near Chubikopi, were also recorded at the same rate (in 1 station, 1 transect). This species is noted at commercial densities of 500–600 /ha in parts of Guadalcanal protected from fishing, and also in French Polynesia and Tonga.

In more protected areas of reef and soft benthos, in areas of fringing reef that were less dynamic, blackfish (*A. miliaris*) were absent and both curryfish (*Stichopus hermanni* and *S. vastus*) were recorded at low density. Even low-value lollyfish (*Holothuria atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*) were uncommon and at low density. No premium-value sandfish (*H. scabra*) were recorded, although suitable sites were noted for this species.

Deeper-water assessments (30 searches of five minutes, average depth 20.3 m, maximum depth 36 m) were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), amberfish (*T. anax*) and elephant trunkfish (*H. fuscopunctata*). Stations were selected where there was both suitably dynamic water movement and oceanic-influenced benthos; *H. fuscogilva* was present in two of five (40%) stations surveyed. White teatfish were not at high density (average 6.4 /ha) and a total of 10 individuals were noted at the stations surveyed. The lower-value and generally more common amberfish (*T. anax*) was present at higher densities as expected, although prickly redfish (*T. ananas*) were again at low density.

5.4.7 Other echinoderms: Chubikopi

The edible collector urchin, *Tripneustes gratilla*, was not recorded, but the slate urchin, *Heterocentrotus mammillatus*, was noted in one reef-front search. The larger black *Echinothrix* spp. (also edible and a habitat-indicator species) were very uncommon (recorded in 10% of stations, average density 4.2 /ha ±2.9). *Echinometra mathaei* and *Diadema* spp. were also noted at higher but still only moderate densities (Appendices 4.4.1 to 4.4.7).

Starfish were common around Chubikopi; the common blue and yellow starfish, *Linckia laevigata* and *L. guildingi*, were recorded in moderate numbers (n = 107) and were moderately common across broad-scale surveys (recorded in 50% of broad-scale stations).

Although *Linckia* spp. are coralivores (coral-eating), pincushion stars (*Culcita novaeguineae*) and crown-of-thorns starfish (*Acanthaster planci*, COTS) are more voracious coral predators, responsible for greater coral damage. *C. novaeguineae* was common and recorded in 92% of broad-scale stations (36% of transects), at a moderate density of 12 /ha ±2.8. COTS were less common (recorded in 1% of broad-scale transects), with a total of forty recorded in all surveys. At no broad-scale survey stations was the density of COTS even close to being abundant enough to qualify for the definition of 'incipient outbreak', meaning the density at which coral damage is likely (0.22 adults per 2-minute manta tow; or >30 adults and sub-adults per hectare). In shallow-water reef-benthos work, COTS were noted at higher density (42–292 /ha), especially across the more oceanic-influenced reefs from Lumalihe passage in the south to Charopoana Island near Uepi in the north.

Table 5.14: Sea cucumber species records for Chubikopi

Species	Common name	Commercial value [5]	B-S transects n = 72			Reef-benthos stations n = 20			Other stations RFs = 7; MOPt = 4			Other stations Ds = 5; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H										0.7	3.6	20 Ds
Actinopyga lecanora	Stonefish	M/H				2.1	41.7	5						
Actinopyga mauritiana	Surf redfish	M/H							0.6	3.9	14 RFs			
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	0.5	16.7	3	2.1	41.7	5	1.1 5.2	3.9 20.8	29 RFs 25 MOPt			
Bohadschia graeffei	Flowerfish	L	0.2	16.7	1	2.1	41.7	5	4.5 5.2	7.8 20.8	57 RFs 25 MOPt			
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	4.6	33.3	14							2.1	10.7	20 Ds
Holothuria atra	Lollyfish	L	8.6	36.2	24	18.8	93.8	20	1.7	11.8	14 RFs	1.4	3.6	40 Ds
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L				4.2	83.3	5				7.9	19.6	40 Ds
Holothuria fuscogilva [4]	White teatfish	H				2.1	41.7	5				6.4	16.1	40 Ds
Holothuria fuscopunctata	Elephant trunkfish	M	0.2	16.7	1							0.7	3.6	20 Ds
Holothuria nobilis [4]	Black teatfish	H												
Holothuria scabra	Sandfish	H												
Stichopus chloronotus	Greenfish	H/M	0.2	16.7	1									
Stichopus hermanni	Curryfish	H/M	0.2	16.7	1									
Stichopus horrens	Peanutfish	M/L										84.4	84.4	100 Ns
Stichopus vastus	Brown curryfish	H/M	0.9	16.7	6							4.4	8.9	50 Ns
Synapta spp.	-	-												
Thelenota ananas	Prickly redfish	H	0.2	16.7	1	2.1	41.7	5	1.1	3.9	29 RFs	0.7	3.6	20 Ds
Thelenota anax	Amberfish	M										14.3	35.7	40 Ds

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) nobilis to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published; [5] L = low value; M = medium value; H = high value; H/M is higher in value than M/H; B-S transects= broad-scale transects; RFs = reef-front search; MOPt = mother-of-pearl transect; Ds = day search; Ns = night search.

5.4.8 Discussion and conclusions: invertebrate resources in Chubikopi

A summary of environmental, stock-status and management factors for the main fisheries is given below. Please note that information on other, smaller fisheries and the status of less prominent species groups can be found in the body of the invertebrate chapter.

In summary, information on giant clam habitat, distribution, density and shell length revealed the following:

- The lagoon at Chubikopi was shallow and generally sandy in nature, with limited areas of reef on coastlines and the barrier. The varied structure and dynamic water movement in some areas presented suitable habitat for the full range of giant clams found in Solomon Islands, although the land-influenced lagoon may at times (especially after heavy rains) present unsuitable conditions.

- The range of clams recorded at the Chubikopi site was restricted, with both *Tridacna derasa* and the true giant clam, *T. gigas*, not recorded in survey. Both can be considered as 'commercially extinct'[15] in this area.

- Giant clam presence and density were low, even considering the nature of the environment. The boring clam, *T. crocea*, which is usually more tolerant of land influence, had moderate densities at a few locations (1.3 clams per 10 m^2), but the elongate clam, *T. maxima*, was recorded at lower density than expected. The same was true for *T. squamosa* and *Hippopus hippopus*, both of which were rare.

- Giant clams are broadcast spawners that only mature as females at larger size classes (protandric hermaphrodites). Clams need larger-sized individuals in their stocks to ensure there is sufficient spawning taking place to produce new generations. Although *T. maxima* displayed a relatively 'full' range of size classes, the larger shell sizes of boring clam (*T. crocea*) were noticeably impacted, and there was no noticeable presence of small *T. squamosa*. Presence of young clams indicates that successful spawning and recruitment is occurring.

Data on MOP distribution, density and shell size suggest the following:

- Local reef conditions at Chubikopi constitute a moderate area for adult and juvenile trochus (*Trochus niloticus*). Trochus were widely distributed on the reefs around Chubikopi, both in the lagoon and on the barrier, and all areas were easily accessible by fishers.

- The general density of trochus on reefs is very low, and no high-density spawning aggregations were identified in survey. High-density aggregations can facilitate faster recovery of stocks if they are protected from fishing.

- Size-class information reveals that recruitment of trochus is not strong and past harvests have comprehensively impacted stocks to a critical threshold where, even without fishing, trochus stocks are unlikely to build in the short term.

[15] Commercially extinct means in this context that the clams were at such a low density as to make them unavailable for any trade and in danger of complete local extinction.

- Most eggs are produced by the largest individuals of a trochus population. This component of the population was found to be currently depleted at Chubikopi, despite regulations being in place to protect these larger shells. Trochus reach the larger size classes (>11 cm basal width) at ≥6 years of age (from shells that would need to survive at least three years in the fishery under the current management scenario). The lack of large older shells, which have the greatest potential to fuel future populations, means that either the level of fishing was so high as to not allow shells to reach this size in the fishery, or there is illegal fishing of larger shell sizes occurring in addition to legal size classes.

- The low commercial value green topshell, *Tectus pyramis*, which has a similar life habit to trochus, was relatively common. The blacklip pearl oyster, *Pinctada margaritifera*, was also common in surveys.

- Green snail (*Turbo marmoratus*), a species commonly recorded in Solomon Islands, was not noted in this survey and is considered commercially extinct in Chubikopi.

In summary, the distribution, density and length recordings of sea cucumbers at Chubikopi revealed the following:

- The range of protected shallow-water and reef habitats made Chubikopi a suitable site for the full range of sea cucumber species typical of Solomon Islands. Although nutrients were not limiting, the land influence may be too dominant for some species, especially as the lagoon in this part of Marovo was relatively shallow.

- Although the range of commercial sea cucumber species at Chubikopi was boosted by the biogeographical position of the site, the number of species recorded was relatively low (n = 17). Many species that are typically recorded in the PROCFish surveys in the Pacific (even if they are depleted through heavy fishing) were absent from Chubikopi (e.g. black teatfish, *Holothuria nobilis*, and sandfish, *H. scabra*).

- Data showed that the distribution of sea cucumbers was patchy, even for species which are typically found spread across varied habitats. The density of the commercial species that were recorded was extremely low.

- The extremely bleak picture of most sea cucumber species and species groups presented by these records suggests that this area will need to close any commercial fishing for a considerable period in the hope of rebuilding viable productivity in the fishery. We have seen that 10-year closures in countries with far less natural advantages (e.g. reef area, nutrient profiles) have resulted in recovery of some stocks. Although there is no set understanding of how quickly these species can recover, the sooner remaining stocks receive protection from fishing the better.

- The long history of the sea cucumber fishery in the Pacific suggests that these fisheries can bounce back from heavy fishing, but the Chubikopi situation presents some of the worst data on depleted stocks (in comparison to the range of data that has been collected in this Pacific overview) and, therefore, drastic management action is needed to ensure there is a future for the sea cucumber fishery in this area.

5.5 Overall recommendations for Chubikopi

- Community fisheries management projects need to be continued and improved with a precautionary approach to resource use advised. Marine protected areas should continue to be established around the uninhabited and not easily accessible islands.

- Biological, fisheries and/or socioeconomic indicators need to be made available to help monitoring and to support precautionary measures to select a number of invertebrate and finfish species for closer surveillance. The mapping of risk zones, i.e. areas within the Chubikopi fishing ground and Marovo lagoon that are potentially the most vulnerable to over-harvesting, may complement current management practices.

- The high population density and the high seafood consumption already results in high fishing pressure per available reef and total fishing ground. Rather than further exploiting marine resources, options to improve marketing and create alternative income opportunities for local people, such as the traditional and marketable wood-carving industry in Chubikopi, need to be explored.

- Cooperation among governmental, NGO and other external institutions, and the Chubikopi community needs to be fostered in order to ensure the success of improved fisheries management.

- Protection measures should be implemented to rebuild the numbers and sizes of clams and reverse the decline. For successful stock management, clams, especially the larger-sized individuals, need to be maintained at higher density than was noted at this section of Marovo lagoon.

- There is presently no scope for commercial trochus fishing at Chubikopi. Strict protection of trochus stocks is needed until the density of trochus in the main aggregations reaches 500–600 /ha. To assist recovery, it may be worthwhile moving some of the remaining adult trochus to make aggregations in areas where they previously occurred.

- Drastic management actions are needed to ensure there is a future for the sea cucumber fishery in Chubikopi, which is among the most depleted in the entire PROCFish study across the Pacific. The fishery will need to be closed for a considerable period (up to 10 years) in the hope of re-building viable productivity in the fishery.

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APPENDIX 1: SURVEY METHODS

1.1 Socioeconomic surveys, questionnaires and average invertebrate wet weights

1.1.1 Socioeconomic survey methods

Preparation

The PROCFish/C socioeconomic survey is planned in close cooperation with local counterparts from national fisheries authorities. It makes use of information gathered during the selection process for the four sites chosen for each of the PROCFish/C participating countries and territories, as well as any information obtained by resource assessments, if these precede the survey.

Information is gathered regarding the target communities, with preparatory work for a particular socioeconomic field survey carried out by the local fisheries counterparts, the project's attachment, or another person charged with facilitating and/or participating in the socioeconomic survey. In the process of carrying out the surveys, training opportunities are provided for local fisheries staff in the PROCFish/C socioeconomic field survey methodology.

Staff are careful to respect local cultural and traditional practices, and follow any local protocols while implementing the field surveys. The aim is to cause minimal disturbance to community life, and surveys have consequently been modified to suit local habits, with both the time interviews are held and the length of the interviews adjusted in various communities. In addition, an effort is made to hold community meetings to inform and brief community members in conjunction with each socioeconomic field survey.

Approach

The design of the socioeconomic survey stems from the project focus, which is on rural coastal communities in which traditional social structures are to some degree intact. Consequently, survey questions assume that the primary sectors (and fisheries in particular) are of importance to communities, and that communities currently depend on coastal marine resources for their subsistence needs. As urbanisation increases, other factors gain in importance, such as migration, as well as external influences that work in opposition to a subsistence-based socioeconomic system in the Pacific (e.g. the drive to maximise income, changes in lifestyle and diet, and increased dependence on imported foods). The latter are not considered in this survey.

The project utilises a 'snapshot approach' that provides 5–7 working days per site (with four sites per country). This timeframe generally allows about 25 households (and a corresponding number of associated finfish and invertebrate fishers) to be covered by the survey. The total number of finfish and invertebrate fishers interviewed also depends on the complexity of the fisheries practised by a particular community, the degree to which both sexes are engaged in finfish and invertebrate fisheries, and the size of the total target population. Data from finfish and invertebrate fisher interviews are grouped by habitat and fishery, respectively. Thus, the project's time and budget and the complexity of a particular site's fisheries are what determine the level of data representation: the larger the population and the number of fishers, and the more diversified the finfish and invertebrate fisheries, the lower the level of representation that can be achieved. It is crucial that this limitation be taken into consideration, because the data gathered through each survey and the emerging distribution patterns are extrapolated to estimate the total annual impact of all fishing activity reported for the entire community at each site.

If possible, people involved in marketing (at local, regional or international scale) who operate in targeted communities are also surveyed (e.g. agents, middlemen, shop owners).

Key informants are targeted in each community to collect general information on the nature of local fisheries and to learn about the major players in each of the fisheries that is of concern, and about fishing rights and local problems. The number of key informants interviewed depends on the complexity and heterogeneity of the community's socioeconomic system and its fisheries.

At each site the extent of the community to be covered by the socioeconomic survey is determined by the size, nature and use of the fishing grounds. This selection process is highly dependent on local marine tenure rights. For example, in the case of community-owned fishing rights, a fishing community includes all villages that have access to a particular fishing ground. If the fisheries of all the villages concerned are comparable, one or two villages may be selected as representative samples, and consequently surveyed. Results will then be extrapolated to include all villages accessing the same fishing grounds under the same marine tenure system.

In an open access system, geographical distance may be used to determine which fishing communities realistically have access to a certain area. Alternatively, in the case of smaller islands, the entire island and its adjacent fishing grounds may be considered as one site. In this case a large number of villages may have access to the fishing ground, and representative villages, or a cross-section of the population of all villages, are selected to be included in the survey.

In addition, fishers (particularly invertebrate fishers) are regularly asked how many people external to the surveyed community also harvest from the same fishing grounds and/or are engaged in the same fisheries. If responses provide a concise pattern, the magnitude of additional impact possibly imposed by these external fishers is determined and discussed.

Sampling

Most of the households included in the survey are chosen by simple random selection, as are the finfish and invertebrate fishers associated with any of these households. In addition, important participants in one or several particular fisheries may be selected for complementary surveying. Random sampling is used to provide an average and representative picture of the fishery situation in each community, including those who do not fish, those engaged in finfish and/or invertebrate fishing for subsistence, and those engaged in fishing activities on a small-scale artisanal basis. This assumption applies provided that selected communities are mostly traditional, relatively small (~100–300 households) and (from a socioeconomic point of view) largely homogenous. Similarly, gender and participation patterns (types of fishers by gender and fishery) revealed through the surveys are assumed to be representative of the entire community. Accordingly, harvest figures reported by male and female fishers participating in a community's various fisheries may be extrapolated to assess the impacts resulting from the entire community, sample size permitting (at least 25–30% of all households).

Data collection and analysis

Data collection is performed using a standard set of questionnaires developed by PROCFish/C's socioeconomic component, which include a household survey (key socioeconomic parameters and consumption patterns), finfish fisheries survey, invertebrate fisheries survey, marketing of finfish survey, marketing of invertebrates survey, and general information questionnaire (for key informants). In addition, further observations and relevant details are noted and recorded in a non-standardised format. The complete set of questionnaires used is attached as Appendix 1.1.2.

Most of the data are collected in the context of face-to-face interviews. Names of people interviewed are recorded on each questionnaire to facilitate cross-identification of fishers and households during data collection and to ensure that each fisher interview is complemented by a household interview. Linking data from household and fishery surveys is essential to permit joint data analysis. However, all names are suppressed once the data entry has been finalised, and thus the information provided by respondents remains anonymous.

Questionnaires are fully structured and closed, although open questions may be added on a case-to-case situation. If translation is required, each interview is conducted jointly by the leader of the project's socioeconomic team and the local counterpart. In cases where no translation is needed, the project's socioeconomist may work individually. Selected interviews may be conducted by trainees receiving advanced field training, but trainees are monitored by project staff in case clarification or support is needed.

The questionnaires are designed to allow a minimum dataset to be developed for each site, one that allows:

- the community's dependency on marine resources to be characterised;
- assessment of the community's engagement in and the possible impact of finfish and invertebrate harvesting; and
- comparison of socioeconomic information with data collected through PROCFish/C resource surveys.

Household survey

The major objectives of the household survey are to:

- **collect recent demographic information** (needed to calculate seafood consumption);
- **determine the number of fishers per household, by gender and type of fishing activity** (needed to assess a community's total fishing impact); and
- **assess the community's relative dependency on marine resources** (in terms of ranked source(s) of income, household expenditure level, agricultural alternatives for subsistence and income (e.g. land, livestock), external financial input (i.e. remittances), assets related to fishing (number and type of boat(s)), and seafood consumption patterns by frequency, quantity and type).

The demographic assessment focuses only on permanent residents, and excludes any family members who are absent more often than they are present, who do not normally share the household's meals or who only join on a short-term visitor basis (for example, students during school holidays, or emigrant workers returning for home leave).

The number of fishers per household distinguishes three categories of adult (≥ 15 years) fishers for each gender: (1) exclusive finfish fishers, (2) exclusive invertebrate fishers, and (3) fishers who pursue both finfish and invertebrate fisheries. This question also establishes the percentage of households that do not fish at all. We use this pattern (i.e. the total number of fishers by type and gender) to determine the number of female and male fishers, and the percentage of these who practise either finfish or invertebrate fisheries exclusively, or who practise both. The share of adult men and women pursuing each of the three fishery categories is presented as a percentage of all fishers. Figures for the total number of people in each fishery category, by gender, are also used to calculate total fishing impact (see below).

The role of fisheries as a source of income in a community is established by a ranking system. Generally, rural coastal communities represent a combined system of traditional (subsistence) and cash-generating activities. The latter are often diversified, mostly involving the primary sector, and are closely associated with traditional subsistence activities. Cash flow is often irregular, tailored to meet seasonal or occasional needs (school and church fees, funerals, weddings, etc.). Ranking of different sources of income by order of importance is therefore a better way to render useful information than trying to quantify total cash income over a certain time period. Depending on the degree of diversification, multiple entries are common. It is also possible for one household to record two different activities (such as fisheries and agriculture) as equally important (i.e. both are ranked as a first source of income, as they equally and importantly contribute to acquisition of cash within the household). In order to demonstrate the degree of diversification and allow for multiple entries, the role that each sector plays is presented as a percentage of the total number of households surveyed. Consequently, the sum of all figures may exceed 100%. Income sources include fisheries, agriculture, salaries, and 'others', with the latter including primarily handicrafts, but sometimes also small private businesses such as shops or kava bars.

Cash income is often generated in parallel by various members of one household and may also be administered by many, making it difficult to establish the overall expenditure level. On the other hand, the head of the household and/or the woman in charge of managing and organising the household are typically aware and in control of a certain amount of money that is needed to ensure basic and common household needs are met. We therefore ask for the level of average household expenditure only, on a weekly, bi-weekly or monthly basis, depending on the payment interval common in a particular community. Expenditures quoted in local currency are converted into US dollars (USD) to enable regional comparison. Conversion factors used are indicated.

Geomorphologic differences between low and high islands influence the role that agriculture plays in a community, but differences in land tenure systems and the particulars of each site are also important, and the latter factors are used in determining the percentage of households that have access to gardens and agricultural land, the average size of these areas, and the type (and if possible number) of livestock that are at the disposal of an average household. A community whose members are equally engaged in agriculture and fisheries will either show distinct groups of fishers and farmers/gardeners, or reveal active and non-active fishing seasons in response to the agricultural calendar.

The frequency and amount of remittances received from family members working elsewhere in the country or overseas enable us to assess the degree to which principles of the MIRAB economy apply. MIRAB was coined to characterise an economy dependent on migration, remittances, foreign aid and government bureaucracy as its major sources of revenue (Small and Dixon 2004; Bertram 1999; Bertram and Watters 1985). A high influx of foreign financing, and in particular remittances, is considered to yield flexible and stable economic conditions at the community level (Evans 2001), and may also substitute for or reduce the need for local income-generating activities, such as fishing.

The number of boats per household is indicative of the level of isolation, and is generally higher for communities that are located on small islands and far from the nearest regional centre and market. The nature of the boats (e.g. non-motorised, handmade dugout canoes, dugouts equipped with sails, and the number and size of any motorised boats) provides insights into the level of investment, and usually relates to the household expenditure level. Having access to boats that are less sensitive to sea conditions and equipped with outboard engines provides greater choice of which fishing grounds to target, decreases isolation and increases independence in terms of transport, and hence provides fishing and marketing advantages. Larger and more powerful boats may also have a multiplication factor, as they accommodate bigger fishing parties. In this context it should be noted that information on boats is usually complemented by a separate boat inventory performed by interviewing key informants and senior members of the community. If possible, we prefer to use the information from the complementary boat inventory surveys rather than extrapolating data from household surveys, in order to minimise extrapolation errors.

A variety of data are collected to characterise the seafood consumption of each community. We distinguish between fresh fish (with an emphasis on reef and lagoon fish species), invertebrates and canned fish. Because meals are usually prepared for and shared by all household members, and certain dishes may be prepared in the morning but consumed throughout the day, we ask for the average quantity prepared for one day's consumption. In the case of fresh fish we ask for the number of fish per size class, or the total weight, usually consumed. However, the weight is rarely known, as most communities are largely self-sufficient in fresh fish supply and local, non-metric units are used for marketing of fish (heap, string, bag, etc.). Information on the number of size classes consumed allows calculation of weight using length–weight relationships, which are known for most finfish species (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). Size classes (using fork length) are identified using size charts (Figure A1.1.1).

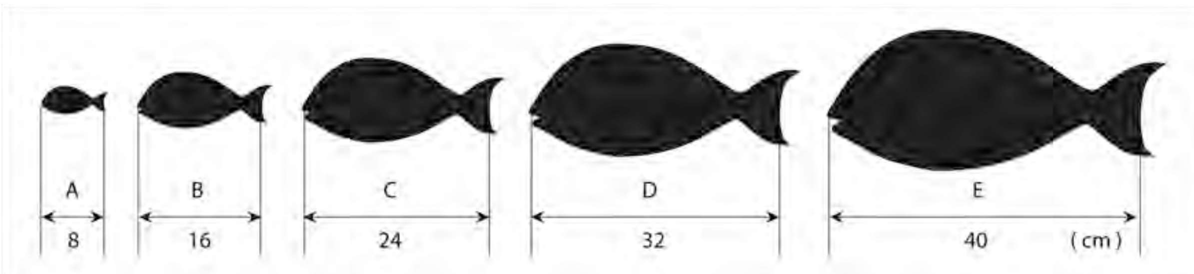


Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

The frequency of all consumption data is adjusted downwards by 17% (a factor of 0.83 determined on the basis that about two months of the year are not used for fishing due to festivities, funerals and bad weather conditions) to take into account exceptional periods throughout the year when the supply of fresh fish is limited or when usual fish eating patterns are interrupted.

Equation for fresh finfish:

$$F_{wj} = \sum_{i=1}^{n} (N_{ij} \bullet W_i) \bullet 0.8 \bullet F_{dj} \bullet 52 \bullet 0.83$$

F_{wj} = finfish net weight consumption (kg edible meat/household/year) for household$_j$
n = number of size classes
N_{ij} = number of fish of size class$_i$ for household$_j$
W_i = weight (kg) of size class$_i$
0.8 = correction factor for non-edible fish parts
F_{dj} = frequency of finfish consumption (days/week) of household$_j$
52 = total number of weeks/year
0.83 = correction factor for frequency of consumption

For invertebrates, respondents provide numbers and sizes or weight (kg) per species or species groups usually consumed. Our calculation automatically transfers these data entries per species/species group into wet weight using an index of average wet weight per unit and species/species group (Appendix 1.1.3).[1] The total wet weight is then automatically further broken down into edible and non-edible proportions. Because edible and non-edible proportions may vary considerably, this calculation is done for each species/species group individually (e.g. compare an octopus that consists almost entirely of edible parts with a giant clam that has most of its wet weight captured in its non-edible shell).

Equation for invertebrates:

$$Inv_{wj} = \sum_{i=1}^{n} E_{p\,i} \bullet (N_{ij} \bullet W_{wi}) \bullet F_{dj} \bullet 52 \bullet 0.83$$

Inv_{wj} = invertebrate weight consumption (kg edible meat/household/year) of household$_j$
E_{pi} = percentage edible (1 = 100%) for species/species group$_i$ (Appendix 1.1.3)
N_{ij} = number of invertebrates for species/species group$_i$ for household$_j$
n = number of species/species group consumed by household$_j$
W_{wi} = wet weight (kg) of unit (piece) for invertebrate species/species group$_i$
1000 = to convert g invertebrate weight into kg
F_{dj} = frequency of invertebrate consumption (days/week) for household$_j$
52 = total number of weeks/year
0.83 = correction factor for consumption frequency

[1] The index used here mainly consists of estimated average wet weights and ratios of edible and non-edible parts per species/species group. At present, SPC's Reef Fishery Observatory is making efforts to improve this index so as to allow further specification of wet weight and edible proportion as a function of size per species/species group. The software will be updated and users informed about changes once input data are available.

Appendix 1: Survey methods
Socioeconomics

Equation for canned fish:

Canned fish data are entered as total number of cans per can size consumed by the household at a daily meal, i.e.:

$$CF_{wj} = \sum_{i=1}^{n} (N_{cij} \bullet W_{ci}) \bullet F_{dcj} \bullet 52$$

CF_{wj} = canned fish net weight consumption (kg meat/household/year) of $household_j$
N_{cij} = number of cans of can $size_i$ for $household_j$
n = number and size of cans consumed by $household_j$
W_{ci} = average net weight (kg)/can $size_i$
F_{dcj} = frequency of canned fish consumption (days/week) for $household_j$
52 = total number of weeks/year

Age-gender correction factors are used because simply dividing total household consumption by the number of people in the household will result in underestimating per head consumption. For example, imagine the difference in consumption levels between a 40-year-old man as compared to a five-year-old child. We use simplified gender-age correction factors following the system established and used by the World Health Organization (WHO; Becker and Helsing 1991), i.e. (Kronen *et al.* 2006):

Age (years)	Gender	Factor
≤5	All	0.3
6–11	All	0.6
12–13	Male	0.8
≥12	Female	0.8
14–59	Male	1.0
≥60	Male	0.8

The per capita finfish, invertebrate and canned fish consumptions are then calculated by selecting the relevant formula from the three provided below:

Finfish per capita consumption:

$$F_{pcj} = \frac{F_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

F_{pcj} = Finfish net weight consumption (kg/capita/year) for $household_j$
F_{wj} = Finfish net weight consumption (kg/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender $class_i$

Invertebrate per capita consumption:

$$Inv_{pcj} = \frac{Inv_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Inv_{pcj} = Invertebrate weight consumption (kg edible meat/capita/year) for $household_j$
Inv_{wj} = Invertebrate weight consumption (kg edible meat/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender $class_i$

Canned fish per capita consumption:

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) for $household_j$
CF_{wj} = canned fish net weight consumption (kg/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age $class_i$ and $household_j$
C_i = correction factor of age-gender $class_i$

The total finfish, invertebrate and canned fish consumption of a known population is calculated by extrapolating the average per capita consumption for finfish, invertebrates and canned fish of the sample size to the entire population.

Total finfish consumption:

$$F_{tot} = \frac{\sum_{j=1}^{n} F_{pcj}}{n_{ss}} \bullet n_{pop}$$

F_{pcj} = finfish net weight consumption (kg/capita/year) for $household_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total invertebrate consumption:

$$Inv_{tot} = \frac{\sum_{j=1}^{n} Inv_{pcj}}{n_{ss}} \bullet n_{pop}$$

Inv_{pcj} = invertebrate weight consumption (kg edible meat/capita/year) for household$_j$

n_{ss} = number of people in sample size

n_{pop} = number of people in total population

Total canned fish consumption:

$$CF_{tot} = \frac{\sum_{j=1}^{n} CF_{pcj}}{n_{ss}} \bullet n_{pop}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) of household$_j$

n_{ss} = number of people in sample size

n_{pop} = number of people in total population

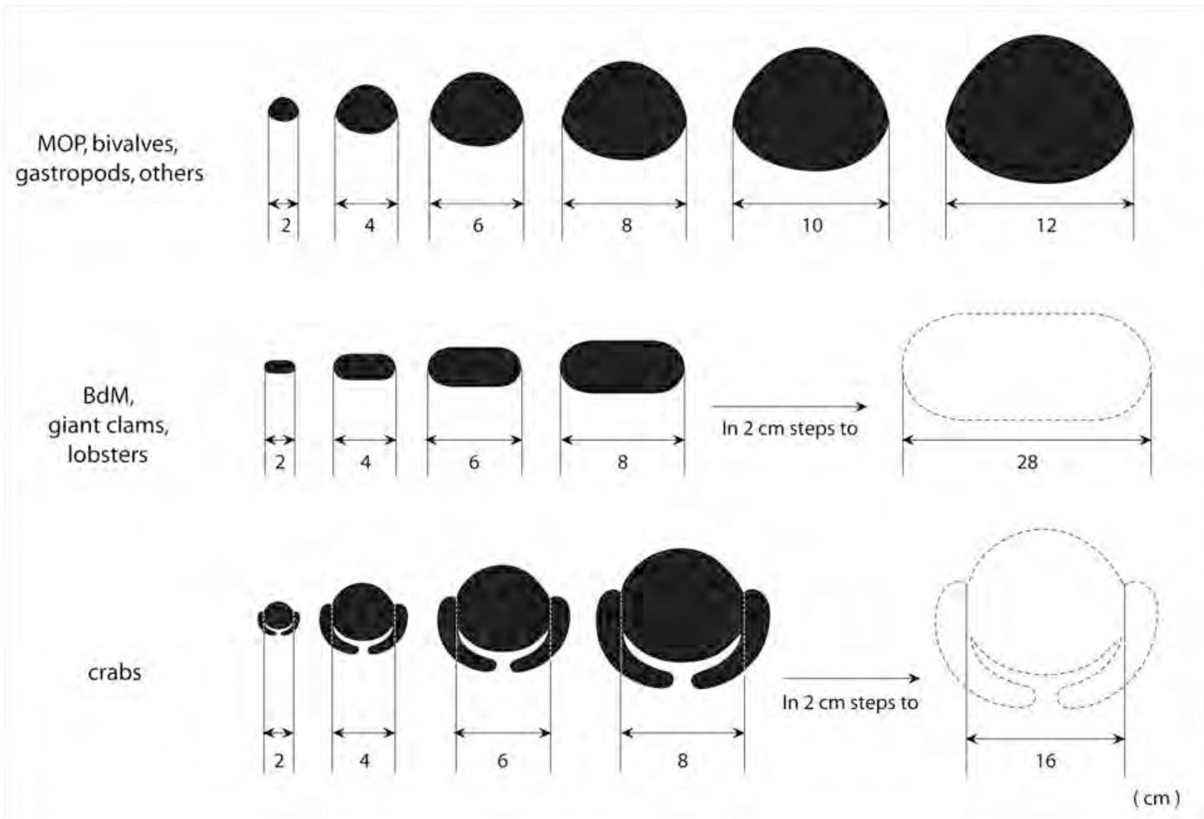


Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

Appendix 1: Survey methods
Socioeconomics

Finfish fisher survey

The finfish fisher survey primarily aims to collect the data needed to understand finfish fisheries strategies, patterns and dimensions, and thus possible impacts on the resource. Data collection faces the challenge of retrieving information from local people that needs to match resource survey parameters, in order to make joint data analysis possible. This challenge is highlighted by the following three major issues:

(i) Fishing grounds are classified by habitat, with the latter defined using geomorphologic characteristics. Local people's perceptions of and hence distinctions between fishing grounds often differ substantially from the classifications developed by the project. Also, fishers do not target particular areas according to their geomorphologic characteristics, but instead due to a combination of different factors including time and transport availability, testing of preferred fishing spots, and preferences of members of the fishing party. As a result, fishers may shift between various habitats during one fishing trip. Fishers also target lagoon and mangrove areas, as well as passages if these are available, all of which cannot be included in the resource surveys. It should be noted that a different terminology for reef and other areas fished is needed to communicate with fishers.

These problems are dealt with by asking fishers to indicate the areas they refer to as coastal reef, lagoon, outer-reef and pelagic fishing on hydrologic charts, maps or aerial photographs. In this way we can often further refine the commonly used terms of coastal or outer reef to better match the geomorphologic classification. The proportion of fishers targeting each habitat is provided as a percentage of all fishers surveyed; the socioeconomic analysis refers to habitats by the commonly used descriptive terms for these habitats, rather than the ecological or geomorphologic classifications.

Fishers may travel between various habitats during a single fishing trip, with differing amounts of time spent in each of the combined habitats; the catch that is retrieved from each combined habitat may potentially vary from one trip to the next. If targeting combined habitats is a common strategy practised by most fishers, the resource data for individual geomorphologic habitats need to be lumped to enable comparison of results.

(ii) People usually provide information on fish by vernacular or common names, which are far less specific than (and thus not compatible with) scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country alone. As a result, one fish species may be associated with a number of vernacular names, but each vernacular name may also apply to more than one species.

This issue is addressed, as much as possible, through indexing the vernacular names recorded during a survey to the scientific names for those species. However, this is not always possible due to inconsistencies between informants. The use of photographic indices is helpful but can also trigger misleading information, due to the variety of photos presented and the limitations of species recognition using photos alone. In this respect, collaboration with local counterparts from fisheries departments is crucial.

(iii) The assessment of possible fishing impacts is based on the collection of average data. Accordingly, fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. This average information suffers from two major shortcomings. Firstly, some fish species are seasonal and may be dominant during a short period of the year but do not necessarily appear frequently in the average catch. Depending on the time of survey implementation this may result in over- or under-representation of these species. Secondly, fishers usually employ more than one technique. Average catches may vary substantially by quantity and quality depending on which technique they use.

We address these problems by recording any fish that plays a seasonal role. This information may be added and helpful for joint interpretation of resource and socioeconomic data. Average catch records are complemented by information on the technique used, and fishers are encouraged to provide the average catch information for the technique that they employ most often.

The design of the finfish fisher survey allows the collection of details on fishing strategies, and quantitative and qualitative data on average catches for each habitat. Targeting men and women fishers allows differences between genders to be established.

Determination of fishing strategies includes:

- frequency of fishing trips
- mode and frequency of transport used for fishing
- size of fishing parties
- duration of the fishing trip
- time of fishing
- months fished
- techniques used
- ice used
- use of catch
- additional involvement in invertebrate fisheries.

The frequency of fishing trips is determined by the number of weekly (or monthly) trips that are regularly made. The average figure resulting from data for all fishers surveyed, per habitat targeted, provides a first impression of the community's engagement in finfish fisheries and shows whether or not different habitats are fished with the same frequency.

Information on the utilisation of non-motorised or motorised boat transport for fishing helps to assess accessibility, availability and choice of fishing grounds. Motorised boats may also represent a multiplication factor as they may accommodate larger fishing parties.

We ask about the size of the fishing party that the interviewee usually joins to learn whether there are particularly active or regular fisher groups, whether these are linked to fishing in certain habitats, and whether there is an association between the size of a fishing party and fishing for subsistence or sale. We also use this information to determine whether information regarding an average catch applies to one or to several fishers.

The duration of a fishing trip is defined as the time spent from any preparatory work through the landing of the catch. This definition takes into account the fact that fishing in a Pacific Island context does not follow a western economic approach of benefit maximisation, but is a more integral component of people's lifestyles. Preparatory time may include up to several hours spent reaching the targeted fishing ground. Fishing time may also include any time spent on the water, regardless of whether there was active fishing going on. The average trip duration is calculated for each habitat fished, and is usually compared to the average frequency of trips to these habitats (see discussion above).

Temporal fishing patterns – the times when most people go fishing – may reveal whether the timing of fishing activities depends primarily on individual time preferences or on the tides. There are often distinct differences between different fisher groups (e.g. those that fish mostly for food or mostly for sale, men and women, and fishers using different techniques). Results are provided in percentage of fishers interviewed for each habitat fished.

To calculate total annual fishing impact, we determine the total number of months that each interviewee fishes. As mentioned earlier, the seasonality of complementary activities (e.g. agriculture), seasonal closing of fishing areas, etc. may result in distinct fishing patterns. To take into account exceptional periods throughout the year when fishing is not possible or not pursued, we apply a correction factor of 0.83 to the total provided by people interviewed (this factor is determined on the basis that about two months of every year – specifically, 304/365 days – are not used for fishing due to festivals, funerals and bad weather conditions).

Knowing the range of techniques used and learning which technique(s) is/are predominantly used helps to identify the possible causes of detrimental impacts on the resource. For example, the predominant use of gillnets, combined with particular mesh sizes, may help to assess the impact on a certain number of possible target species, and on the size classes that would be caught. Similarly, spearfishing targets particular species, and the impacts of spearfishing on the abundance of these species in the habitats concerned may become evident. To reveal the degree to which fishers use a variety of different techniques, the percentage of techniques used refers to the proportion of all fishers who use that technique. Percentages show which techniques are used by most or even all fishers, and which are used by smaller groups. In addition, the data are presented by habitat (what percentage of fishers targeting a habitat use a particular technique, where n = the total number of fishers interviewed by habitat).

The use of ice (whether it is used at all, used infrequently or used regularly) hints at the degree of commercialisation, available infrastructure and investment level. Usually, communities targeted by our project are remote and rather isolated, and infrastructure is rudimentary. Thus, ice needs to be purchased and is often obtained from distant sources, with attendant costs in terms of transport and time. On the other hand, ice may be the decisive input that allows marketing at a regional or urban centre. The availability of ice may also be a decisive factor in determining the frequency of fishing trips.

Determining the use of the catch or shares thereof for various purposes (subsistence, non-monetary exchange and sale) is a necessary prerequisite to providing fishery management advice. Fishing pressure is relatively stable if determined predominantly by the community's subsistence demand. Fishing is limited by the quantity that the community can consume, and changes occur in response to population growth and/or changes in eating habits. In contrast, if fishing is performed mainly for external sale, fishing pressure varies according to outside market demand (which may be dynamic) and the cost-benefit (to fishers) of fishing. Fishing strategies may vary accordingly and significantly. The recorded purposes of fishing are presented as the percentage of all fishers interviewed per habitat fished. We distinguish these figures by habitat so as to allow for the fact that one fisher may fish several habitats but do so for different purposes.

Information on the additional involvement of interviewed fishers in invertebrate fisheries, for either subsistence or commercial purposes, helps us to understand the subsistence and/or commercial importance of various coastal resources. The percentage of finfish fishers who also harvest invertebrates is calculated, with the share of these who do so for subsistence and/or for commercial purposes presented in percentage (the sum of the latter percentages may exceed 100, because fishers may harvest invertebrates for both subsistence and sale).

The average catch per habitat (technique and transport used) is recorded, including:

- a list of species, usually by vernacular names; and
- the kg or number per size class for each species.

These data are used to calculate total weight per species and size class, using a weight–length conversion factor (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). This requires using the vernacular/scientific name index to relate (as far as possible) local names to their scientific counterparts. Fish length is reported by using size charts that comprise five major size classes in 8 cm intervals, i.e. 8 cm, 16 cm, 24 cm, 32 cm and 40 cm. The length of any fish that exceeds the largest size class (40 cm) presented in the chart is individually estimated using a tape measure. The length–weight relationship is calculated for each site using a regression on catch records from finfish fishers' interviews weighted by the annual catch. Data used from the catch records consist of scientific names correlated to the vernacular names given by fishers, number of fish, size class (or measured size) and/or weight. In other words, we use the known length–weight relationship for the corresponding species to vernacular names recorded.

Once we have established the average and total weight per species and size class recorded, we provide an overview of the average size for each family. The resulting pattern allows analysis of the degree to which average and relative sizes of species within the various families present at a particular site are homogeneous. The same average distribution pattern is calculated for all families, per habitat, in order to reveal major differences due to the locations where the fish were caught. Finally, we combine all fish records caught, per habitat and site, to determine what proportion of the extrapolated total annual catch is composed of each of the various size classes. This comparison helps to establish the most dominant size class caught overall, and also reveals major differences between the habitats present at a site.

Catch data are further used to calculate the total weight for each family (includes all species reported) and habitat. We then convert these figures into the percentage distribution of the total annual catch, by family and habitat. Comparison of relative catch composition helps to identify commonalities and major differences, by habitat and between those fish families that are most frequently caught.

A number of parameters from the household and fisher surveys are used to calculate the total annual catch volume per site, habitat, gender, and use of the catch (for subsistence and/or commercial purposes).

Appendix 1: Survey methods
Socioeconomics

Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed are extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey are used to determine what proportion of men and women fishers target various habitats or combinations of habitats. These figures are assumed to be representative of the community as a whole, and hence are applied to the total number of fishers (as determined by the household survey). The total number of finfish fishers is the sum of all fishers who solely target finfish, and those who target both finfish and invertebrates; the same system is applied for invertebrate fishers (i.e. it includes those who collect only invertebrates and those who target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

<u>Total annual catch (t/year):</u>

$$\text{TAC} = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

TAC = total annual catch t/year
Fif_h = total number of female fishers for habitat_h
Acf_h = average annual catch of female fishers (kg/year) for habitat_h
Fim_h = total number of male fishers for habitat_h
Acm_h = average annual catch of male fishers (kg/year) for habitat_h
N_h = number of habitats

Where:

$$\text{Acf}_h = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cfi}{If_h} \bullet \frac{\sum_{k=1}^{Rf_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

If_h = number of interviews of female fishers for habitat_h (total number of interviews where female fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported on interview_i
Fm_i = number of months fished (reported in interview_i)
Cf_i = average catch reported in interview_i (all species)
Rf_h = number of targeted habitats as reported by female fishers for habitat_h (total numbers of interviews where female fishers reported targeting habitat_h but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat_k
Fm_k = number of months fished for reported habitat_k (fishers = sum of finfish fishers and mixed fishers, i.e. people pursuing both finfish and invertebrate fishing)

Thus, we obtain the total annual catch by habitat and gender group. The sum of all catches from all habitats and both genders equals the total annual impact of the community on its fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

<u>Total annual finfish export:</u>

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

Where:

E = total annual export (t)
TAC = total annual catch (t)
F_{tot} = total annual finfish consumption (net weight kg)
$\frac{1}{0.8}$ = to calculate total biomass/weight, i.e. compensate for the earlier deduction by 0.8 to determine edible weight parts only

In order to establish <u>fishing pressure</u>, we use the habitat areas as determined by satellite interpretation. However, as already mentioned, resource surveys and satellite interpretation do not include lagoon areas. Thus, we determine the missing areas by calculating the smallest possible polygon (Figure A1.1.3) that encompasses the total fishing ground determined with fishers and local people during the fieldwork. In cases where fishing grounds are gazetted, owned and managed by the community surveyed, the missing areas are determined using the community's fishing ground limits.

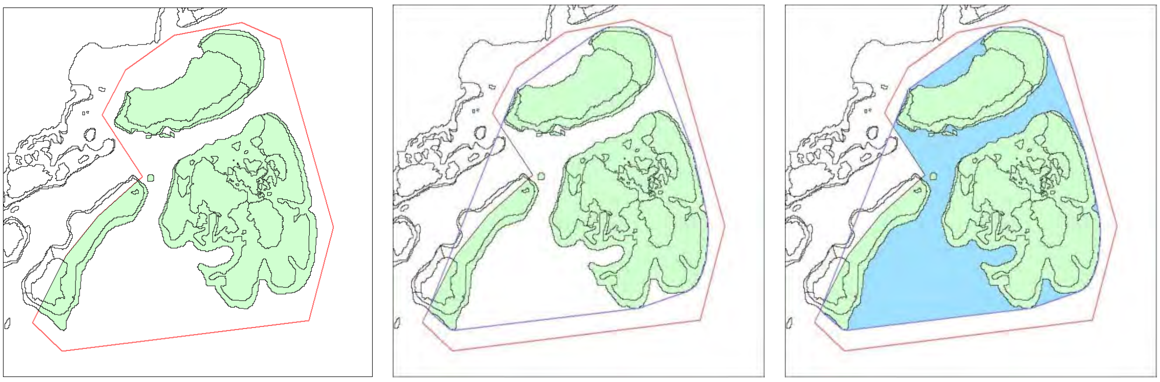


Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as lagoon (in blue) (Developed using MapInfo).

We use the calculated total annual impact and fishing ground areas to determine relative fishing pressure. Fishing pressure indicators include the following:

- annual catch per habitat
- annual catch per total reef area
- annual catch per total fishing ground area.

Fisher density includes the total number of fishers per km^2 of reef and total fishing ground area, and productivity is the annual catch per fisher. Due to the lack of baseline data, we compare selected indicators, such as fisher density, productivity (catch per fisher and year) and total annual catch (per reef and total fishing ground area), across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The catch per unit effort (CPUE) is generally acknowledged as an indicator of the status of a resource. If an increasing amount of time is required to obtain a certain catch, degradation of the resource is assumed. However, taking into account that our project is based on a snapshot approach, CPUE is used on a comparative basis between sites within a country, and will be employed later on a regional scale. Its application and interpretation must also take into account the fact that fishing in the Pacific Islands does not necessarily follow efficiency or productivity maximisation strategies, but is often an integral component of people's lifestyles. As a result, CPUE has limited applicability.

In order to capture comparative data, in calculating CPUE we use the entire time spent on a fishing trip, including travel, fishing and landing. Thus, we divide the total average catch per fisher by the total average time spent per fishing trip. CPUE is determined as an overall average figure, by gender and habitat fished.

Invertebrate fisher survey

The objective, purpose and design of the invertebrate fisher survey largely follow those of the finfish fisher survey. Thus, the primary aim of the invertebrate fisher survey is to collect data needed to understand the strategies, patterns and dimensions of invertebrate fisheries, and hence the possible impacts on invertebrate resources. Invertebrate data collection faces several challenges, as retrieval of information from local people needs to match the resource survey parameters in order to enable joint data analysis. Some of the major issues are:

Appendix 1: Survey methods
Socioeconomics

(i) The invertebrate resource survey defines invertebrate fisheries using differing parameters (several are primarily determined by habitat, others by target species). However, these fisheries classifications do not necessarily coincide with the perceptions and fishing strategies of local people. In general, there are two major types of invertebrate fishers: those who walk and collect with simple tools, and those who free-dive using masks, fins, snorkel, hands, simple tools or spears. The latter group is often more commercially oriented, targeting species that are exploited for export (trochus, BdM, lobster, etc.). However, some of the divers may harvest invertebrates as a by-product of spearfishing for finfish. Fishers who primarily walk (some may or may not use non-motorised or even motorised transport to reach fishing grounds) are mainly gleaners targeting available habitats (or a combination of habitats, if convenient). While gleaning is often performed for subsistence needs, it may also be used as a source of income, albeit mostly serving national rather than export markets. While gleaning is an activity that may be performed by both genders, diving is usually men's domain.

We have addressed the problem of collecting information according to fisheries as defined by the resource survey by asking people to report according to the major habitats they target and/or species-specific dive fisheries they engage in. Very often this results in the grouping of various fisheries, as they are jointly targeted or performed on one fishing trip. Where possible, we have disaggregated data for these groups and allocated individuals to specific fisheries. Examples of such data disaggregation are the proportion of all fishers and fishers by gender targeting each of the possible fisheries at one site.

We have also disaggregated some of the catch data, because certain species are always or mostly associated with a particular fishery. However, the disagreement between people's perception and the resource classification becomes visible when comparing species composition per fishery (or combination of fisheries) as reported by interviewed fishers, and the species and total annual wet weight harvested allocated individually by fishery, as defined by the resource survey.

(ii) As is true for finfish, people usually provide information on invertebrate species by vernacular or common names, which are far less specific and thus not directly compatible with scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country. Differing from finfish, vernacular names for invertebrates usually combine a group (often a family) of species, and are rarely species specific.

Similar to finfish, the issue of vernacular versus scientific names is addressed by trying to index as many scientific names as possible for any vernacular name recorded during the ongoing survey. Inconsistencies between informants are a limiting factor. The use of photographic indices is very useful, but may trigger misleading information; in addition, some reported species may not be depicted. Again, collaboration with local counterparts from fisheries departments is crucial.

The lack of specificity in the vernacular names used for invertebrates is an issue that cannot be resolved, and specific information regarding particular species that are included with others under one vernacular name cannot be accurately provided.

(iii) The assessment of possible fishing impacts is based on the collection of average data. This means that fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. In the case of invertebrate fisheries this results in underestimation of the total number of species caught, and often greater attention is given to commercial species than to rare species that are used mainly for consumption. Seasonality of invertebrate species appears to be a less important issue than when compared to finfish.

We address these problems by encouraging people to also share with us the names of species they may only rarely catch.

(iv) Assessment of possible fishing impact requires knowledge of the size–weight relationship of (at least) the major species groups harvested. Unfortunately, a comparative tool (such as FishBase and others that are used for finfish) is not available for invertebrates. In addition, the proportion of edible and non-edible parts varies considerably among different groups of invertebrates. Further, non-edible parts may still be of value, as for instance in the case of trochus. However, these ratios are also not readily available and hence limit current data analysis.

We have dealt with this limitation by applying average weights (drawn from the literature or field measurements) for certain invertebrate groups. The applied wet weights are listed in Appendix 1.1.3. We used this approach to estimate total biomass (wet weight) removed; we have also listed approximations of the ratio between edible and non-edible biomass for each species.

Information on invertebrate fishing strategies by fishery and gender includes:

- frequency of fishing trips
- duration of an average fishing trip
- time when fishing
- total number of months fished per year
- mode of transport used
- size of fishing parties
- fishing external to the community's fishing grounds
- purpose of the fisheries
- whether or not the fisher also targets finfish.

In addition, for each fishery (or combination of fisheries) the species composition of an average catch is listed, and the average catch for each fishery is specified by number, size and/or total weight. If local units such as bags (plastic bags, flour bags), cups, bottles or buckets are used, the approximate weight of each unit is estimated and/or weighed during the field survey and average weight applied accordingly. For size classes, size charts for different species groups are used (Figure A1.1.2).

The proportion of fishers targeting each fishery (as defined by the resource survey) is presented as a percentage of all fishers. Records of fisheries that are combined in one trip are disaggregated by counting each fishery as a single data entry. The same process is applied to determine the share of women and men fishers per fishery (as defined by the resource survey).

Appendix 1: Survey methods
Socioeconomics

The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialised harvesting strategies. This distribution is particularly interesting when comparing gleaning fisheries, while commercial dive fisheries are species specific by definition.

The calculation of catch volumes is based on the determination of the total number of invertebrate fishers and fishers targeting both finfish and invertebrates, by gender group and by fishery, as described above.

The average invertebrate catch composition by number, size and species (with vernacular names transferred to scientific nomenclature), and by fishery and gender group, is extrapolated to include all fishers concerned. Conversion of numbers and species by average weight factors (Appendix 1.1.3) results in a determination of total biomass (wet weight) removed, by fishery and by gender. The sum of all weights determines the total annual impact, in terms of biomass removed.

To calculate total annual impact, we determine the total numbers of months fished by each interviewee. As mentioned above, seasonality of complementary activities, seasonal closing of fishing areas, etc. may result in distinct fishing patterns. Based on data provided by interviewees, we apply – as for finfish – a correction factor of 0.83 to take into account exceptional periods throughout the year when fishing is not possible or not pursued (this is determined on the basis that about two months (304/365 days) of each year are not used for fishing due to festivals, funerals and bad weather conditions).

Total annual catch:

$$\text{TACj} = \sum_{h=1}^{N_h} \frac{F_{inv}f_h \bullet Ac_{inv}f_{hj} + F_{inv}m_h \bullet Ac_{inv}m_{hj}}{1000}$$

TACj = total annual catch t/year for $species_j$
$F_{inv}f_h$ = total number of female invertebrate fishers for $habitat_h$
$Ac_{inv}f_{hj}$ = average annual catch by female invertebrate fishers (kg/year) for $habitat_h$ and $species_j$
$F_{inv}m_h$ = total number of male invertebrate fishers for $habitat_h$
$Ac_{inv}m_{hj}$ = average annual catch by male invertebrate fishers (kg/year) for $habitat_h$ and $species_j$
N_h = number of habitats

Where:

$$Ac_{inv}f_{hj} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv}f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = number of interviews of female invertebrate fishers for $habitat_h$ (total numbers of interviews where female invertebrate fishers provided detailed information for $habitat_h$)
f_i = frequency of fishing trips (trips/week) as reported in $interview_i$

Fm_i = number of months fished as reported in interview$_i$
Cf_{ij} = average catch reported for species$_j$ as reported in interview$_i$
$R_{inv}f_h$ = number of targeted habitats reported by female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers reported targeting habitat$_h$ but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat$_k$
Fm_k = number of months fished for reported habitat$_k$

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names to scientific nomenclature. Size frequency distributions are provided for the most important species, by total annual weight removed, expressed in percentage of each size group of the total annual weight harvested. The size frequency distribution may reveal the impact of fishing pressure for species that are represented by a wide size range (from juvenile to adult state). It may also be a useful parameter to compare the status of a particular species or species group across various sites at the national or even regional level.

To further determine fishing strategies, we also inquire about the purpose of harvesting each species (as recorded by vernacular name). Results are depicted as the proportion (in kg/year) of the total annual biomass (net weight) removed for each purpose: consumption, sale or both. We also provide an index of all species recorded through fisher interviews and their use (in percentage of total annual weight) for any of the three categories.

In order to gain an idea of the productivity of and differences between the fisheries practices used in each site we calculate the average annual catch per fisher, by gender and fishery. This calculation is based on the total biomass (net weight) removed from each fishery and the total number of fishers by gender group.

For invertebrate species that are marketed, detailed information is collected on total numbers (weight and/or combination of number and size), processing level, location of sale or client, frequency of sales and price received per unit sold. At this stage of our project we do not fully analyse this marketing information. However, prices received for major commercial species, as well as an approximation of sale volumes by fishery and fisher, help to assess what role invertebrate fisheries (or a particular fishery) play(s) in terms of income generation for the surveyed community, and in comparison to the possible earnings from finfish fisheries.

We use the calculated total annual impact in combination with the fishing ground area to determine relative fishing pressure. Fishing pressure indicators are calculated as the annual catch per km^2 for each area that is considered to support any of the fisheries present at each study site. In some instances (e.g. intertidal fisheries), areas are replaced by linear km; accordingly, fishing pressure is then related to the length (in km) of the supporting habitat. Due to the lack of baseline data, we compare selected indicators, such as the fisher density (number of fishers per km^2 – or linear km – of fishing ground, for each fishery), productivity (catch per fisher and year) and total annual catch per fishery, across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The differing nature of invertebrate species that may be caught during one fishing trip, and hence the great variability between edible and non-edible, useful and non-useful parts of species caught, make the determination of CPUE difficult. Substantial differences in the economic value of species add another challenge. We have therefore refrained from calculating CPUE values at this stage of the project.

Data entry and analysis

Data from all questionnaire forms are entered in the Reef Fisheries Integrated Database (RFID) system. All data entered are first verified and 'cleaned' prior to analysis. In the process of data entry, a comprehensive list of vernacular and corresponding scientific names for finfish and invertebrate species is developed.

Database queries have been defined and established that allow automatic retrieval of the descriptive statistics used when summarising results at the site and national levels.

1.1.2 Socioeconomic survey questionnaires

- Household census and consumption survey
- Finfish fishing and marketing survey (for fishers)
- Invertebrate fishing and marketing survey (for fishers)
- Fisheries (finfish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HH NO. ☐

Name of head of household: ________________ Village: _________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? *(must be living there; tick box)* male ☐ female ☐

2. How old is the head of household? *(enter year of birth)* ☐

3. How many people ALWAYS live in your household? *(enter number)* ☐

4. How many are male and how many are female? (*tick box and enter age in years or year of birth)*

male	age	female	age
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐

5. Does this household have any agricultural land?

yes ☐ no ☐

6. How much (*for this household only*)?

for permanent/regular cultivation ☐ (unit)

for permanent/regular livestock ☐ (unit)

type of animals__________ no. ☐

7. How many fishers live in your household? ☐
(*enter number of people who go fishing/collecting regularly)*

invertebrate fishers		finfish fishers		invertebrate & finfish fishers	
M	F	M	F	M	F
☐	☐	☐	☐	☐	☐

8. Does this household own a boat? yes ☐ no ☐

9a. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9b. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9c. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP

10. Where does the CASH money in this household come from? (*rank options, 1 = most money, 2 = second important income source, 3 = 3rd important income source, 4 = 4th important income source*)

Fishing/seafood collection ☐

Agriculture (crops & livestock) ☐

Salary ☐

Others (handicrafts, etc.) ☐ specify: ____________________

11. Do you get remittances? yes ☐ no ☐

12. How often?	1 per month	1 per 3 months	1 per 6 months	other *(specify)*
	☐	☐	☐	☐

13. How much? *(enter amount)* Every time? (currency) [ ]

14. How much CASH money do you use on average for household expenditures (food, fuel for cooking, school bus, etc.)?

(currency) [ ] per week/2-weekly/month (or? specify_______)

15. What is the educational level of your household members?

no. of people	having achieved:
[ ]	elementary/primary education
[ ]	secondary education
[ ]	tertiary education (college, university, special schools, etc.)

CONSUMPTION SURVEY

16. During an average/normal week, on how many days do you prepare fish, other seafood and canned fish for your family? *(tick box)*

	7 days	6 days	5 days	4 days	3 days	2 days	1 day	other, specify
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

17. Mainly at	breakfast	lunch	supper
Fresh fish	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]

18. How much do you cook on average per day for your household? *(tick box)*

	number	kg	size: A	B	C	D	E	>E (cm)
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Other seafood

name:	no.	size	kg	plastic bag ¼	½	¾	1
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐

19. Canned fish   No. of cans: ☐   Size of can: ☐ small
☐ medium
☐ big

20. Where do you normally get your fish and seafood from?

Fish:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

Invertebrates:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

21. Which is the last day you had fish? ______________________

22. Which is the last day you had other seafood? ______________________

–THANK YOU–

FISHING (FINFISH) AND MARKETING SURVEY

Name: ____________________ F ☐ M ☐ **HH NO.** ☐

Name of head of household: _______________________ Village: ______________

Surveyor's name: _____________________ Date: ______________

1. Which areas do you fish?

coastal reef	lagoon	outer reef	mangrove	pelagic
☐	☐	☐	☐	☐

2. Do you go to only one habitat per trip?

Yes ☐ no ☐

3. If no, how many and which habitats do you visit during an average trip?

total no.	habitats:	coastal reef	lagoon	mangrove	outer reef
☐		☐	☐	☐	☐

4. How often (days/week) do you fish in each of the habitats visited?

coastal reef	lagoon	mangrove	outer reef	
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month

5. Do you use a boat for fishing?

	Always	sometimes	never
coastal reef	☐	☐	☐
lagoon	☐	☐	☐
mangrove	☐	☐	☐
outer reef	☐	☐	☐

6. If you use a boat, which one?

1 { canoe (paddle) ☐ sailing ☐
motorised ☐ HP outboard ☐ 4-stroke engine ☐ }

coastal reef ☐ lagoon ☐ outer reef ☐

2
- canoe (paddle) ☐ sailing ☐
- motorised ☐ HP outboard ☐ 4-stroke engine ☐

coastal reef ☐ lagoon ☐ outer reef ☐

3
- canoe (paddle) ☐ sailing ☐
- motorised ☐ HP outboard ☐ 4-stroke engine ☐

coastal reef ☐ lagoon ☐ outer reef ☐

7. How many fishers ALWAYS go fishing with you?

Names:____

INFORMATION BY FISHERY **Name of fisher: ______________** **HH NO.** ☐

coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

1. HOW OFTEN do you normally go out FISHING for this habitat? *(tick box)*

Every Day	5 days/ week	4 days/ week	3 days/ week	2 days/ week	1 day/ week	other, specify:
☐	☐	☐	☐	☐	☐	____________________

2. What time do you spend fishing this habitat per average trip? ____________________
(if the fisher can't specify, tick a box)

<2 hrs	2–6 hrs	6–12 hrs	>12 hrs
☐	☐	☐	☐

3. WHEN do you go fishing? *(tick box)* day ☐ night ☐ day & night ☐

4. Do you go all year?

Yes ☐ no ☐

5. If no, which months <u>don't</u> you fish?

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Which fishing techniques do you use (*in the habitat referred to here*)?

☐ handline

☐ castnet ☐ gillnet

☐ spear (dive) ☐ longline

☐ trolling ☐ spear (handheld) walking ☐ canoe ☐

☐ deep bottom line ☐ poison: which one? ______________

☐ other, specify: ____

7. Do you use more than one technique per trip for this habitat? If yes, which ones usually?

☐ one technique/trip ☐ more than one technique/trip:

____

8. Do you use ice on your fishing trips?

☐ always ☐ sometimes ☐ never

☐ is it homemade? ☐ or bought?

9. What is your average catch (kg) per trip? ☐ Kg OR:

size class:	A	B	C	D	E	>E (cm)
number:	☐	☐	☐	☐	☐	☐

10. Do you sell fish? yes ☐ no ☐

11. Do you give fish as a gift (for no money)? yes ☐ no ☐

12. Do you use your catch for family consumption? yes ☐ no ☐

13. How much of your usual catch do you keep for family consumption?

kg ☐ OR:

size class	A	B	C	D	E	>E (cm)
no	☐	☐	☐	☐	☐	☐

and the rest you gift? yes ☐

how much? kg ☐ OR:

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

and/or sell? yes ☐

how much? kg ☐ OR:

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

14. What sizes of fish do you use for your family consumption, what for sale and what do you give away without getting any money?

size classes:	all	A	B	C	D	E	and larger (no. and cm)
consumption	☐	☐	☐	☐	☐	☐	☐
sale	☐	☐	☐	☐	☐	☐	☐
give away	☐	☐	☐	☐	☐	☐	☐

15. You sell where?

☐ inside village ☐ outside village where? ____________________________

and to whom?

market ☐ agents/middlemen ☐ shop owners ☐ others ☐ ___________

16. In an average catch what fish do you catch, and how much of each species? *(write down the species in the table)*

technique usually used:_____________________ boat type usually used:________________
habitat usually fished: ____

Specify the number by size

Name of fish	kg	A	B	C	D	E	>E cm

20. Do you also fish invertebrates?

Yes ☐ no ☐ if yes for consumption? ☐ sale? ☐

–THANK YOU–

INVERTEBRATE FISHING AND MARKETING SURVEY FISHERS

HH NO. ☐

Name: ____

Gender: ☐ female ☐ male Age: ☐

Village: ____

Date: ________________ Surveyor's name: ____________________

Invertebrates = everything that is not a fish with fins!

1. Which type of fisheries do you do?

☐ seagrass gleaning ☐ mangrove & mud gleaning

☐ sand & beach gleaning ☐ reeftop gleaning

☐ bêche-de mer diving ☐ mother-of-pearl diving trochus, pearl shell, etc.

☐ lobster diving ☐ other, such as clams, octopus

2. *(if more than one fishery in question 1):* Do you usually go fishing at only one of the fisheries or do you visit several during one fishing trip?

☐ one only ☐ several

If several fisheries at a time, which ones do you combine?

----

3. How often do you go gleaning/diving (*tick as from questions 1 and 2 above and watch for combinations*) and for how long, and do you also finfish at the same time?

	times/week		duration in hours				glean/dive at			fish no. of months/year
	(*if the fisher can't specify, tick the box*)		<2	2–4	4–6	>6	D	N	D&N	
☐ seagrass gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mangrove & mud gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ sand & beach gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ reeftop gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ bêche-de-mer diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ lobster diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ other diving (clams, octopus)	☐	____	☐	☐	☐	☐	☐	☐	☐	________

D = day, N = night, D&N = day and night (no preference but fish with tide)

4. Do you sometimes go gleaning/fishing for invertebrates outside your village fishing grounds?

yes ☐ no ☐

If yes, where? ____

5. Do you finfish? yes ☐ no ☐

for: ☐ consumption? ☐ sale?

at the same time? yes ☐ no ☐

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 1: EACH FISHERY PER FISHER INTERVIEWED: ☐ **HH NO. __Name of fisher: ______________** **gender: F** ☐ **M** ☐

What transport do you mainly use? ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

How many fishers are usually on a trip? (total no.) ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

Appendix 1: Survey methods
Socioeconomics

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HH NO**. ☐ **Name of fisher:** ________________________

Copy all species that have been named for 'SALE' in previous sheet

Who markets your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ other __________________

Species for sale – copy from sheet 2 (for each fishery per fisher) above	Processing level of product sold (see list)	Where do you sell? (see list)	How often? Days/week?	How much each time? Quantity/unit	Price

FISHERIES (FINFISH AND INVERTEBRATE AND SOCIOECONOMICS) GENERAL INFORMATION SURVEY

Target group: key people, groups of fishers, fisheries officers, etc.

1. Are there management rules that apply to your fisheries? Do they specifically target finfish or invertebrates, or do they target both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think – do people obey:

traditional/village management rules?

mostly ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules?

mostly ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And do you know why?

4. What are the main techniques used by the community for:

a) finfishing

gillnets – most-used mesh sizes:

What is usually used for bait? And is it bought or caught?

b) invertebrate fishing → ***see end!***

5. Please give a quick inventory and characteristics of boats used in the community (length, material, motors, etc.).

Seasonality of species

What are the **FINFISH** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

Seasonality of species

What are the **INVERTEBRATE** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

How many people carry out the invertebrate fisheries below, from inside and from outside the community?

GLEANING	**no. from this village**	**no.**	**from village**	**no.**	**from village**
☐ seagrass gleaning	☐	☐	______	☐	______
☐ mangrove & mud gleaning	☐	☐	______	☐	______
☐ sand & beach gleaning	☐	☐	______	☐	______
☐ reeftop gleaning	☐	☐	______	☐	______
DIVING					
☐ bêche-de-mer diving	☐	☐	______	☐	______
☐ lobster diving	☐	☐	______	☐	______
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	☐	______	☐	______
☐ other (clams, octopus)	☐	☐	______	☐	______

What gear do invertebrate fishers use? *(tick box of technique per fishery)*

GLEANING (soft bottom = seagrass)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

GLEANING (soft bottom = mangrove & mud)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

GLEANING (soft bottom = sand & beach)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

GLEANING (hard bottom = reeftop)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (bêche-de-mer)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (lobster)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (mother-of-pearl, trochus, pearl shell, etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

DIVING (other, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

Any traditional/customary/village fisheries?

Name:

Season/occasion:

Frequency:

Quantification of marine resources caught:

Species name	Size	Quantity (unit?)

1.1.3 Average wet weight applied for selected invertebrate species groups

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Acanthopleura gemmata	29	35	65	10.15	Chiton
Actinopyga lecanora	300	10	90	30	BdM [(1)]
Actinopyga mauritiana	350	10	90	35	BdM [(1)]
Actinopyga miliaris	300	10	90	30	BdM [(1)]
Anadara spp.	21	35	65	7.35	Bivalves
Asaphis violascens	15	35	65	5.25	Bivalves
Astralium spp.	20	25	75	5	Gastropods
Atactodea striata, *Donax cuneatus,* *Donax cuneatus*	2.75	35	65	0.96	Bivalves
Atrina vexillum, *Pinctada margaritifera*	225	35	65	78.75	Bivalves
Birgus latro	1000	35	65	350	Crustacean
Bohadschia argus	462.5	10	90	46.25	BdM [(1)]
Bohadschia spp.	462.5	10	90	46.25	BdM [(1)]
Bohadschia vitiensis	462.5	10	90	46.25	BdM [(1)]
Cardisoma carnifex	227.8	35	65	79.74	Crustacean
Carpilius maculatus	350	35	65	122.5	Crustacean
Cassis cornuta, *Thais aculeata,* *Thais aculeata*	20	25	75	5	Gastropods
Cerithium nodulosum, *Cerithium nodulosum*	240	25	75	60	Gastropods
Chama spp.	25	35	65	8.75	Bivalves
Codakia punctata	20	35	65	7	Bivalves
Coenobita spp.	50	35	65	17.5	Crustacean
Conus miles, *Strombus gibberulus gibbosus*	240	25	75	60	Gastropods
Conus spp.	240	25	75	60	Gastropods
Cypraea annulus, *Cypraea moneta*	10	25	75	2.5	Gastropods
Cypraea caputserpensis	15	25	75	3.75	Gastropods
Cypraea mauritiana	20	25	75	5	Gastropods
Cypraea spp.	95	25	75	23.75	Gastropods
Cypraea tigris	95	25	75	23.75	Gastropods
Dardanus spp.	10	35	65	3.5	Crustacean
Dendropoma maximum	15	25	75	3.75	Gastropods
Diadema spp.	50	48	52	24	Echinoderm
Dolabella auricularia	35	50	50	17.5	Others
Donax cuneatus	15	35	65	5.25	Bivalves
Drupa spp.	20	25	75	5	Gastropods
Echinometra mathaei	50	48	52	24	Echinoderm
Echinothrix spp.	100	48	52	48	Echinoderm
Eriphia sebana	35	35	65	12.25	Crustacean
Gafrarium pectinatum	21	35	65	7.35	Bivalves
Gafrarium tumidum	21	35	65	7.35	Bivalves
Grapsus albolineatus	35	35	65	12.25	Crustacean
Hippopus hippopus	500	19	81	95	Giant clams
Holothuria atra	100	10	90	10	BdM [(1)]
Holothuria coluber	100	10	90	10	BdM [(1)]

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Holothuria fuscogilva	2000	10	90	200	BdM (1)
Holothuria fuscopunctata	1800	10	90	180	BdM (1)
Holothuria nobilis	2000	10	90	200	BdM (1)
Holothuria scabra	2000	10	90	200	BdM (1)
Holothuria spp.	2000	10	90	200	BdM (1)
Lambis lambis	25	25	75	6.25	Gastropods
Lambis spp.	25	25	75	6.25	Gastropods
Lambis truncata	500	25	75	125	Gastropods
Mammilla melanostoma, Polinices mammilla	10	25	75	2.5	Gastropods
Modiolus auriculatus	21	35	65	7.35	Bivalves
Nerita albicilla, Nerita polita	5	25	75	1.25	Gastropods
Nerita plicata	5	25	75	1.25	Gastropods
Nerita polita	5	25	75	1.25	Gastropods
Octopus spp.	550	90	10	495	Octopus
Panulirus ornatus	1000	35	65	350	Crustacean
Panulirus penicillatus	1000	35	65	350	Crustacean
Panulirus spp.	1000	35	65	350	Crustacean
Panulirus versicolor	1000	35	65	350	Crustacean
Parribacus antarcticus	750	35	65	262.5	Crustacean
Parribacus caledonicus	750	35	65	262.5	Crustacean
Patella flexuosa	15	35	65	5.25	Limpet
Periglypta puerpera, Periglypta reticulate	15	35	65	5.25	Bivalves
Periglypta spp., *Periglypta* spp., *Spondylus* spp., *Spondylus* spp.,	15	35	65	5.25	Bivalves
Pinctada margaritifera	200	35	65	70	Bivalves
Pitar proha	15	35	65	5.25	Bivalves
Planaxis sulcatus	15	25	75	3.75	Gastropods
Pleuroploca filamentosa	150	25	75	37.5	Gastropods
Pleuroploca trapezium	150	25	75	37.5	Gastropods
Portunus pelagicus	227.83	35	65	79.74	Crustacean
Saccostrea cucullata	35	35	65	12.25	Bivalves
Saccostrea spp.	35	35	65	12.25	Bivalves
Scylla serrata	700	35	65	245	Crustacean
Serpulorbis spp.	5	25	75	1.25	Gastropods
Sipunculus indicus	50	10	90	5	Seaworm
Spondylus squamosus	40	35	65	14	Bivalves
Stichopus chloronotus	100	10	90	10	BdM (1)
Stichopus spp.	543	10	90	54.3	BdM (1)
Strombus gibberulus gibbosus	25	25	75	6.25	Gastropods
Strombus luhuanus	25	25	75	6.25	Gastropods
Tapes literatus	20	35	65	7	Bivalves
Tectus pyramis, Trochus niloticus	300	25	75	75	Gastropods
Tellina palatum	21	35	65	7.35	Bivalves

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Tellina spp.	20	35	65	7	Bivalves
Terebra spp.	37.5	25	75	9.39	Gastropods
Thais armigera	20	25	75	5	Gastropods
Thais spp.	20	25	75	5	Gastropods
Thelenota ananas	2500	10	90	250	BdM (1)
Thelenota anax	2000	10	90	200	BdM (1)
Tridacna maxima	500	19	81	95	Giant clams
Tridacna spp.	500	19	81	95	Giant clams
Trochus niloticus	200	25	75	50	Gastropods
Turbo crassus	80	25	75	20	Gastropods
Turbo marmoratus	20	25	75	5	Gastropods
Turbo setosus	20	25	75	5	Gastropods
Turbo spp.	20	25	75	5	Gastropods

BdM = Bêche-de-mer; (1) edible part of dried Bêche-de-mer, i.e. drying process consumes about 90% of total wet weight; hence 10% are considered as the edible part only.

1.2 Methods used to assess the status of finfish resources

Fish counts

In order to count and size fish in selected sites, we use the **distance-sampling underwater visual census (D-UVC)** method (Kulbicki and Sarramegna 1999, Kulbicki *et al.* 2000), fully described in Labrosse *et al.* (2002). Briefly, the method consists of recording the species name, abundance, body length and the distance to the transect line for each fish or group of fish observed; the transect consists of a 50 m line, represented on the seafloor by an underwater tape (Figure A1.2.1). For security reasons, two divers are required to conduct a survey, each diver counting fish on a different side of the transect. Mathematical models are then used to estimate fish density (number of fish per unit area) and biomass (weight of fish per unit area) from the counts.

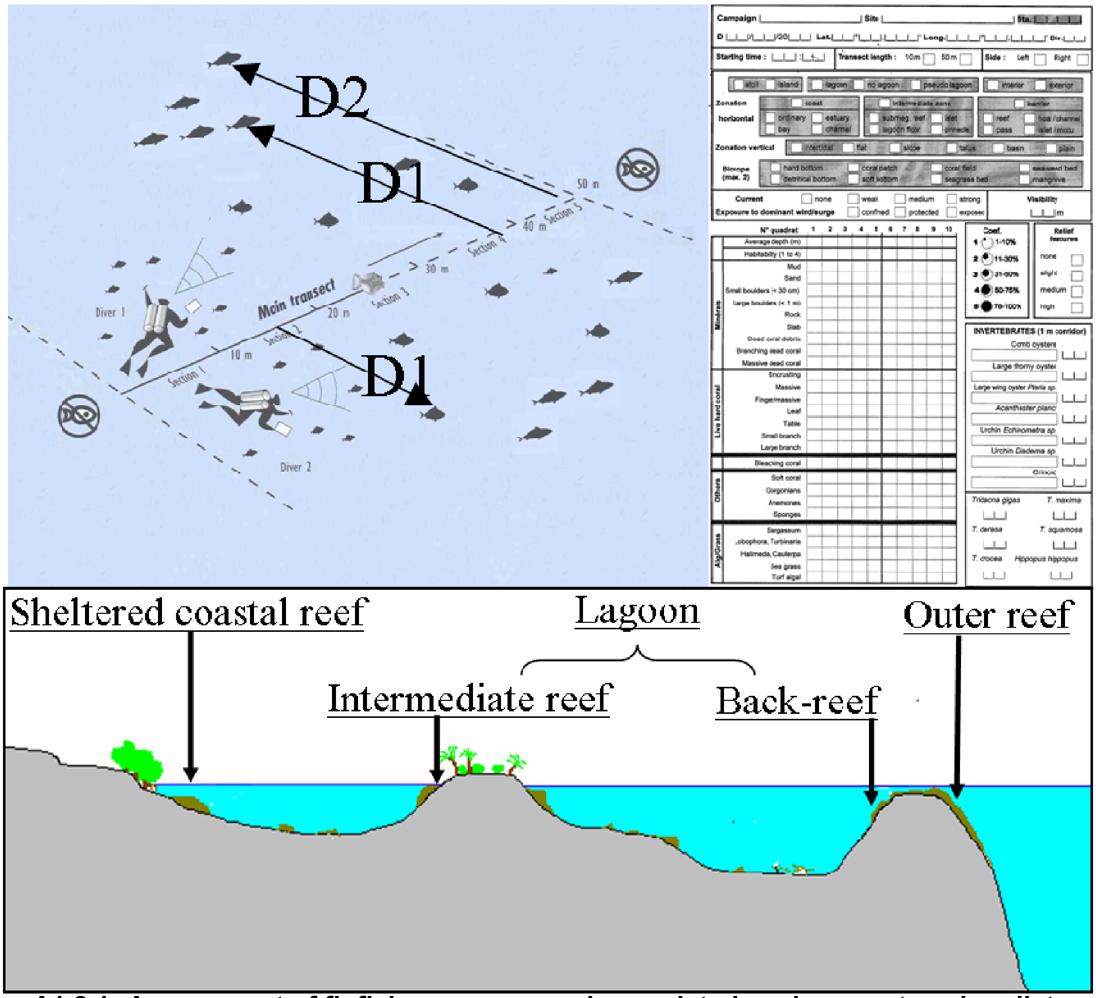


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys are conducted along 24 transects, with six transects in each of the four main geomorphologic coral reef structures: sheltered coastal reefs, intermediate reefs and back-reefs (lumped into the 'lagoon reef' category of socioeconomic assessment), and outer reefs. D1 is the distance of an observed fish from the transect line. If a school of fish is observed, D1 is the distance from the transect line to the closest fish; D2 the distance to the furthest fish.

Appendix 1: Survey methods
Finfish

Species selection

Only reef fish of interest for consumption or sale and species that could potentially serve as indicators of coral reef health are surveyed (see Table A1.2.1; Appendix 3.2 provides a full list of counted species and abundance for each site surveyed).

Table A1.2.1: List of finfish species surveyed by distance sampling underwater visual census (D-UVC)
Most frequently observed families on which reports are based are highlighted in yellow.

Family	Selected species
Acanthuridae	All species
Aulostomidae	*Aulostomus chinensis*
Balistidae	All species
Belonidae	All species
Caesionidae	All species
Carangidae	All species
Carcharhinidae	All species
Chaetodontidae	All species
Chanidae	All species
Dasyatidae	All species
Diodontidae	All species
Echeneidae	All species
Ephippidae	All species
Fistulariidae	All species
Gerreidae	*Gerres* spp.
Haemulidae	All species
Holocentridae	All species
Kyphosidae	All species
Labridae	*Bodianus axillaris, Bodianus loxozonus, Bodianus perditio, Bodianus* spp., *Cheilinus:* all species, *Choerodon:* all species, *Coris aygula, Coris gaimard, Epibulus insidiator, Hemigymnus:* all species, *Oxycheilinus diagrammus, Oxycheilinus* spp.
Lethrinidae	All species
Lutjanidae	All species
Monacanthidae	*Aluterus scriptus*
Mugilidae	All species
Mullidae	All species
Muraenidae	All species
Myliobatidae	All species
Nemipteridae	All species
Pomacanthidae	*Pomacanthus semicirculatus, Pygoplites diacanthus*
Priacanthidae	All species
Scaridae	All species
Scombridae	All species
Serranidae	Epinephelinae: all species
Siganidae	All species
Sphyraenidae	All species
Tetraodontidae	*Arothron*: all species
Zanclidae	All species

Appendix 1: Survey methods
Finfish

Analysis of percentage occurrence in surveys at both regional and national levels indicates that of the initial 36 surveyed families, only 15 families are frequently seen in country counts. Since low percentage occurrence could either be due to rarity (which is of interest) or low detectability (representing a methodological bias), we decided to restrict our analysis to the 15 most frequently observed families, for which we can guarantee that D-UVC is an efficient resource assessment method.

These are:

- Acanthuridae (surgeonfish)
- Balistidae (triggerfish)
- Chaetodontidae (butterflyfish)
- Holocentridae (squirrelfish)
- Kyphosidae (drummer and seachubs)
- Labridae (wrasse)
- Lethrinidae (sea bream and emperor)
- Lutjanidae (snapper and seaperch)
- Mullidae (goatfish)
- Nemipteridae (coral bream and butterfish)
- Pomacanthidae (angelfish)
- Scaridae (parrotfish)
- Serranidae (grouper, rockcod, seabass)
- Siganidae (rabbitfish)
- Zanclidae (moorish idol).

Substrate

We used the **medium-scale approach** (MSA) to record substrate characteristics along transects where finfish were counted by D-UVC. MSA has been developed by Clua *et al.* (2006) to specifically complement D-UVC surveys. Briefly, the method consists of recording depth, habitat complexity, and 23 substrate parameters within ten 5 x 5 m quadrats located on each side of a 50 m transect, for a total of 20 quadrats per transect (Figure A1.2.1). The transect's habitat characteristics are then calculated by averaging substrate records over the 20 quadrats.

Parameters of interest

In this report, the status of finfish resources has been characterised using the following seven parameters:

- **biodiversity** – the number of families, genera and species counted in D-UVC transects;
- **density** (fish/m^2) – estimated from fish abundance in D-UVC;
- **size** (cm fork length) – direct record of fish size by D-UVC;
- **size ratio** (%) – the ratio between fish size and maximum reported size of the species. This ratio can range from nearly zero when fish are very small to nearly 100 when a given fish has reached the greatest size reported for the species. Maximum reported size (and source of reference) for each species are stored in our database;

- **biomass** (g/m²) – obtained by combining densities, size, and weight–size ratios (Weight–size ratio coefficients are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit);
- **community structure** – density, size and biomass compared among families; and
- **trophic structure** – density, size and biomass compared among trophic groups. Trophic groups are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit. Each species was classified into one of five broad trophic groups: 1) carnivore (feed predominantly on zoobenthos), 2) detritivore (feed predominantly on detritus), 3) herbivore (feed predominantly on plants), 4) piscivore (feed predominantly on nekton, other fish and cephalopods) and 5) plankton feeder (feed predominantly on zooplankton). More details on fish diet can be found online at: http://www.fishbase.org/manual/english/FishbaseThe_FOOD_ITEMS_Table.htm.

The relationship between environment quality and resource status has not been fully explored at this stage of the project, as this task requires complex statistical analyses on the regional dataset. Rather, the living resources assessed at all sites in each country are placed in an environmental context via the description of several crucial habitat parameters. These are obtained by grouping the original 23 substrate parameters recorded by divers into the following six parameters:

- **depth** (m)
- **soft bottom** (% cover) – sum of substrate components:
  (1) mud (sediment particles <0.1 mm), and
  (2) sand and gravel (0.1 mm <hard particles <30 mm)
- **rubble and boulders** (% cover) – sum of substrate components:
  (3) dead coral debris (carbonated structures of heterogeneous size, broken and removed from their original locations),
  (4) small boulders (diameter <30 cm), and
  (5) large boulders (diameter <1 m)
- **hard bottom** (% cover) – sum of substrate components:
  (6) slab and pavement (flat hard substratum with no relief), rock (massive minerals) and eroded dead coral (carbonated edifices that have lost their coral colony shape),
  (7) dead coral (dead carbonated edifices that are still in place and retain a general coral shape), and
  (8) bleaching coral
- **live coral** (% cover) – sum of substrate components:
  (9) encrusting live coral,
  (10) massive and sub-massive live corals,
  (11) digitate live coral,
  (12) branching live coral,
  (13) foliose live coral,
  (14) tabulate live coral, and
  (15) *Millepora* spp.
- **soft coral** (% cover) – substrate component:
  (16) soft coral.

Sampling design

Coral reef ecosystems are complex and diverse. The NASA Millennium Coral Reef Mapping Project (MCRMP) has identified and classified coral reefs of the world in about 1,000 categories. These very detailed categories can be used directly to try to explain the status of living resources or be lumped into more general categories to fit a study's particular needs. For the needs of the finfish resource assessment, MCRMP reef types were grouped into the four main coralline geomorphologic structures found in the Pacific (Figure A1.2.2):

- **sheltered coastal reef**: reef that fringes the land but is located inside a lagoon or a pseudo-lagoon
- **lagoon reef**:
  - **intermediate reef** – patch reef that is located inside a lagoon or a pseudo-lagoon, and
  - **back-reef** – inner/lagoon side of outer reef
- **outer reef**: ocean side of fringing or barrier reefs.

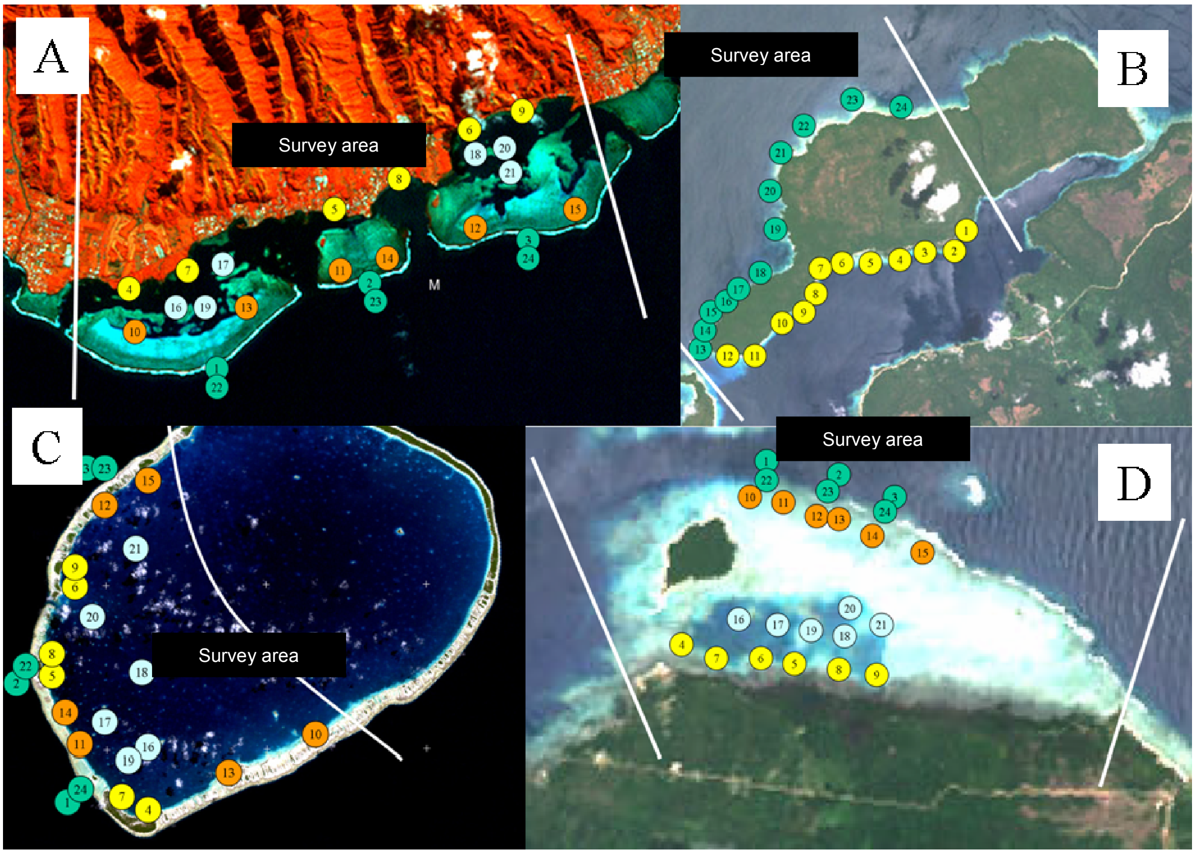


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon back-reef transects in orange and outer-reef transects in green. Transect locations are determined using satellite imagery prior to going into the field, which greatly enhances fieldwork efficiency. The white lines delimit the borders of the survey area.

Fish and associated habitat parameters are recorded along 24 transects per site, with a balanced design among the main geomorphologic structures present at a given site (Figure A1.2.2). For example, our design results in at least six transects in each of the sheltered coastal, lagoon intermediate, lagoon back-reef, and outer reefs of islands with lagoons (Figure A1.2.2A) or 12 transects in each of the sheltered coastal and outer reefs of islands with pseudo-lagoons (Figure A1.2.2B). This balanced, stratified and yet flexible sampling design was chosen to optimise the quality of the assessment, given the logistical and time constraints that stem from the number and diversity of sites that have to be covered over the life of the project. The exact position of transects is determined in advance using satellite imagery, to assist in locating the exact positions in the field; this maximises accuracy and allows replication for monitoring purposes (Figure A1.2.2).

Scaling

Maps from the Millennium Project allow the calculation of reef areas in each studied site, and those areas can be used to scale (using weighted averages) the resource assessment at any spatial level. For example, the average biomass (or density) of finfish at site (i.e. village) level would be calculated by relating the biomass (or density) recorded in each of the habitats sampled at the site ('the data') to the proportion of surface of each type of reef over the total reef present in the site ('the weights'), by using a weighted average formula. The result is a village-level figure for finfish biomass that is representative of both the intrinsic characteristics of the resource and its spatial distribution. Technically, the weight given to the average biomass (or density) of each habitat corresponds to the ratio between the total area of that reef habitat (e.g. the area of sheltered coastal reef) and the total area of reef present (e.g. the area of sheltered coastal reef + the area of intermediate reef, etc.). Thus the calculated weighted biomass value for the site would be:

$$B_{Vk} = \sum j_l \, [B_{Hj} \bullet S_{Hj}] \, / \sum_j S_{Hj}$$

Where:

B_{Vk} = computed biomass or fish stock for village k
B_{Hj} = average biomass in habitat H_j
S_{Hj} = surface of that habitat H_j

A comparative approach only

Density and biomass estimated by D-UVC for each species recorded in the country are given in Appendix 3.2. However, it should be stressed that, since estimates of fish density and biomass (and other parameters) are largely dependent upon the assessment method used (this is true for any assessment), the resource assessment provided in this report can only be used for management in a comparative manner. Densities, biomass and other figures given in this report provide only estimates of the available resource; it would be a great mistake (possibly leading to mismanagement) to consider these as true indicators of the actual available resource.

Campaign |________| Site |________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|' WT |__|__|__|

Starting time : |__|__| :|__|__| — Visibility |__|__| m — Side : Left ☐ Right ☐

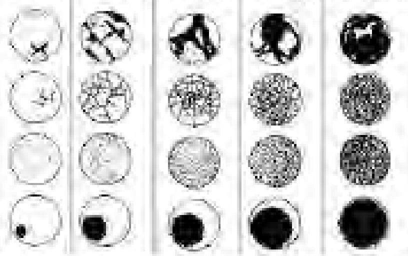
☐ coast		☐ intermediate zone		☐ barrier	
☐ linear	☐ cape	☐ submerg. reef	☐ pinnacle	☐ outer slope	☐ pass
☐ bay mouth	☐ back of bay	☐ near surf. reef	☐ islet lagoon	☐ reef crest	☐ hoa/channel
☐ estuary	☐ channel	☐ lagoon floor	☐ islet fringing reef	☐ back reef	☐ motu

☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

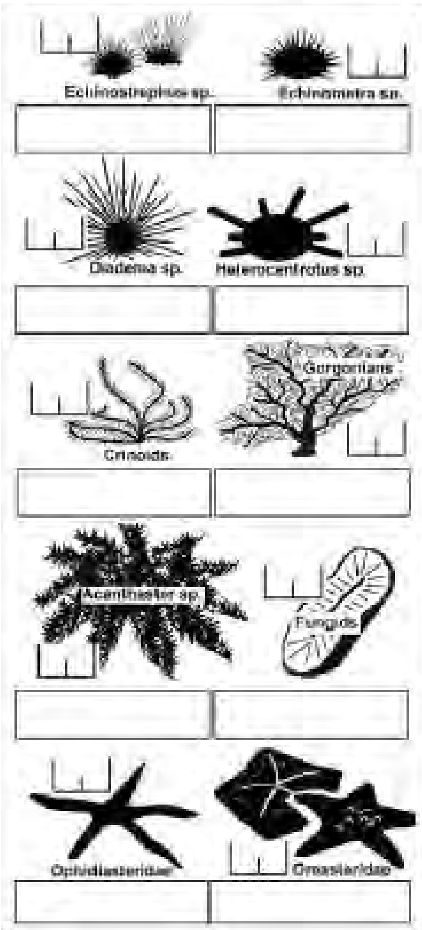
☐ hard bottom	☐ large coral patches	☐ small coral patches	☐ coral field	☐ seaweed bed
☐ detritical bottom	☐ soft bottom		☐ seagrass bed	☐ mangrove

	current	relief features	exposure to dominant wind	oceanic influence	terrigenous influence
none	☐	☐	☐	☐	☐
medium	☐	☐	☐	☐	☐
strong	☐	☐	☐	☐	☐

1	2	3	4	5
1-10%	11-30%	31-50%	51-75%	76-100%



Quadrat limits	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Average depth (m)										
Habitability (1 to 4)										
General coverage										
Mud										
Sand										
Dead coral debris										
Small boulders (< 30 cm)										
Large boulders (< 1 m)										
Eroded dead coral, rock										
Old dead coral in place										
Bleaching coral										
(1) Live corals										
(2) Soft invertebrates										
(1) Live corals										
Encrusting										
Massive										
Digitate										
Branch										
Foliose										
Tabulate										
Millepora sp.										
(2)										
Soft corals										
Sponges										
Grass/alg										
Cyanophyceae										
Sea grass										
Encrusting algae										
Small macro-algae										
Large macro-algae										
Drifting algae										
Micro-algae, Turf										
Others :										



Appendix 1: Survey methods
Finfish

Campaign |____________________| Site |______________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|__|' Left ☐ Right ☐

ST	SCIENTIFIC NAME	NBER	LGT	D1	D2	COMMENTS

1.3 Invertebrate resource survey methods

1.3.1 Methods used to assess the status of invertebrate resources

Introduction

Coastal communities in the Pacific access a range of invertebrate resources. Within the PROCFish/C study, a range of survey methods were used to provide information on key invertebrate species commonly targeted. These provide information on the status of resources at scales relevant to species (or species groups) and the fishing grounds being studied that can be compared across sites, countries and the region, in order to assess relative status.

Species data resulting from the resource survey are combined with results from the socioeconomic survey of fishing activity to describe invertebrate fishing activity within specific 'fisheries'. Whereas descriptions of commercially orientated fisheries are generally recognisable in the literature (e.g. the sea cucumber fishery), results from non-commercial stocks and subsistence-orientated fishing activities (e.g. general reef gleaning) will also be presented as part of the results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examined invertebrate stocks (and fisheries) for approximately seven days at each site, with at least two research officers (SPC Invertebrate Biologist and Fisheries Officer) plus officers from the local fisheries department. The work completed at each site was determined by the availability of local habitats and access to fishing activity.

Two types of survey were conducted: fishery-dependent surveys and fishery independent surveys.

- Fishery-dependent surveys rely on information from those engaged in the fishery, e.g. catch data;
- Fishery-independent surveys are conducted by the researchers independently of the activity of the fisheries sector.

Fishery-dependent surveys were completed whenever the opportunity arose. This involved accompanying fishers to target areas for the collection of invertebrate resources (e.g. reef-benthos, soft-benthos, trochus habitat). The location of the fishing activity was marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record was useful in helping to determine the species complement targeted by fishers, particularly in less well-defined 'gleaning' fisheries. A CPUE record, with related information on individual animal sizes and weights, provided an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fishery-dependent surveys were compared with records from fishery-independent surveys, in order to assess which sizes fishers were targeting.

For a number of reasons, not all fisheries lend themselves to independent snapshot assessments: density measures may be difficult to obtain (e.g. crab fisheries in mangrove systems) or searches may be greatly influenced by conditions (e.g. weather, tide and lunar conditions influence lobster fishing). In the case of crab or shoreline fisheries, searches are very subjective and weather and tidal conditions affect the outcome. In such cases, observed and reported catch records were used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers was to gain a first-hand insight into local fishing activities and facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding independent resource assessment was generally more forthcoming than when trying to gather information using maps and aerial photographs while in the village. Fishery-independent surveys were not conducted randomly over a defined site 'study' area. Therefore assistance from knowledgeable fishers in locating areas where fishing was common was helpful in selecting areas for fishery-independent surveys.

A series of fishery-independent surveys (direct, in-water resource assessments) were conducted to determine the status of targeted invertebrate stocks. These surveys needed to be wide ranging within sites to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and well replicated as invertebrates are often highly aggregated (even within a single habitat type).

PROCFish/C assessments do not aim to determine the size of invertebrate populations at study sites. Instead, these assessments aim to determine the status of invertebrates within the main fishing grounds or areas of naturally higher abundance. The implications of this approach are important, as the haphazard measures taken in main fishing grounds are indicative of stock health in these locations only and should not be extrapolated across all habitats within a study site to gain population estimates.

This approach was adopted due to the limited time allocated for surveys and the study's goal of 'assessing the status of invertebrate resources' (as opposed to estimating the standing stock). Making judgements on the status of stocks from such data relies on the assumption that the state of these estimates of 'unit stock'[2] reflects the health of the fishery. For example, an overexploited trochus fishery would be unlikely to have high-density 'patches' of trochus, just as a depleted shallow-reef gleaning fishery would not hold high densities of large clams. Conversely, a fishery under no stress would be unlikely to be depleted or show skewed size ratios that reflected losses of the adult component of the stock.

In addition to examining the density of species, information on spatial distribution and size/weight was collected, to add confidence to the study's inferences.

The basic assumption that looking at a unit stock will give a reliable picture of the status of that stock is not without weaknesses. Resource stocks may appear healthy within a much-restricted range following stress from fishing or environmental disturbance (e.g. a cyclone), and historical information on stock status is not usually available for such remote locations. The lack of historical datasets also precludes speculation on 'missing' species, which may be 'fished-out' or still remain in remnant populations at isolated locations within study sites.

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[2] As used here, 'unit stock' refers to the biomass and cohorts of adults of a species in a given area that is subject to a well-defined fishery, and is believed to be distinct and have limited interchange of adults from biomasses or cohorts of the same species in adjacent areas (Gulland 1983).

As mentioned, specific independent assessments were not conducted for mud crab and shore crabs (mangrove fishery), lobster or shoreline stocks (e.g. nerites, surf clams and crabs), as limited access or the variability of snapshot assessments would have limited relevance for comparative assessments.

Generic terminology used for surveys: site, station and replicates

Various methods were used to conduct fishery-independent assessments. At each site, surveys were generally made within specific areas (termed 'stations'). At least six replicate measures were made at each station (termed 'transects', 'searches' or 'quadrats', depending on the resource and method) (Figure A1.3.1).

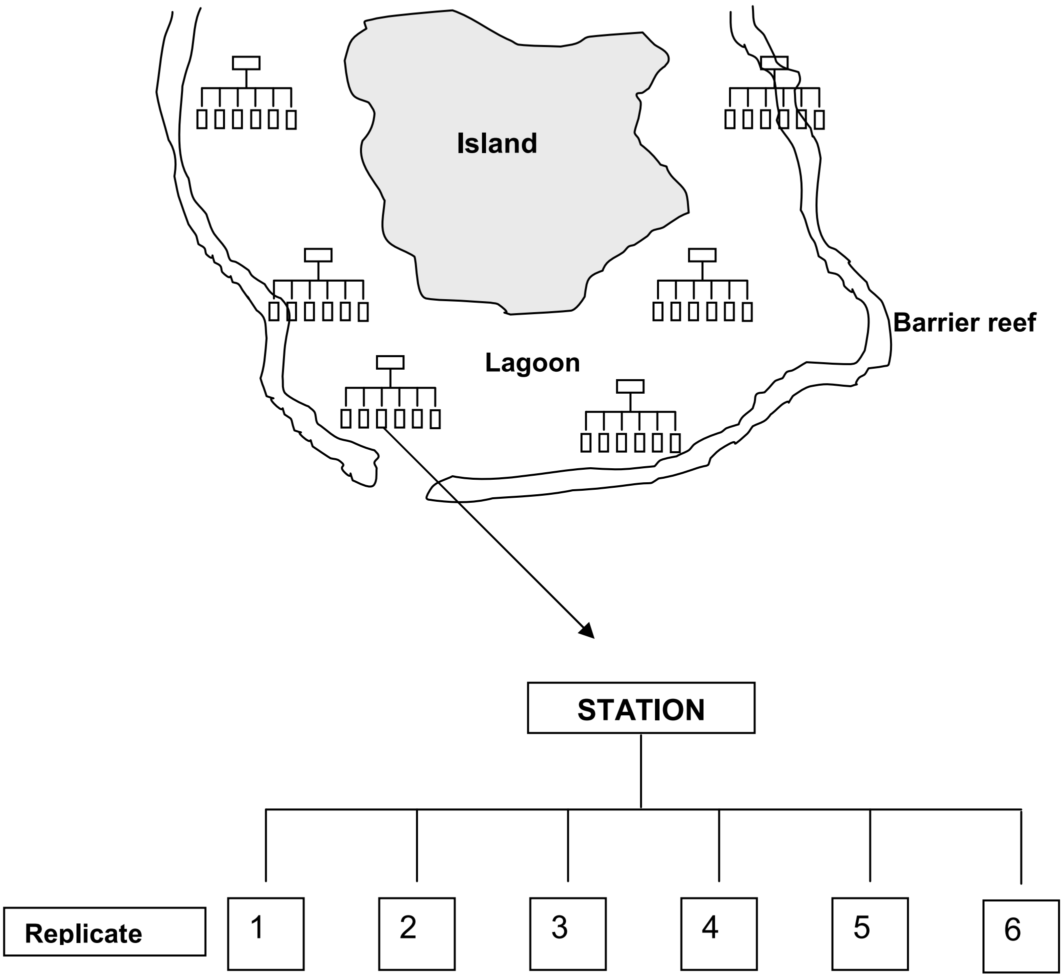


Figure A1.3.1: Stations and replicate measures at a given site.
Note: a replicate measure could be a transect, search period or quadrat group.

Invertebrate species diversity, spatial distribution and abundance were determined using fishery-independent surveys at stations over broad-scale and more targeted surveys. Broad-scale surveys aimed to record a range of macro invertebrates across sites, whereas more targeted surveys concentrated on specific habitats and groups of important resource species.

Recordings of habitat are generally taken for all replicates within stations (see Appendix 1.3.3). Comparison of species complements and densities among stations and sites does not factor in fundamental differences in macro and micro habitat, as there is presently no established method that can be used to make allowances for these variations. The complete dataset from PROCFish/C will be a valuable resource to assess such habitat effects, and by identifying salient habitat factors that reliably affect resource abundance, we may be able to account for these habitat differences when inferring 'status' of important species groups. This will be examined once the full Pacific dataset has been collected.

More detailed explanations of the various survey methods are given below.

Broad-scale survey

Manta 'tow-board' transect surveys

A general assessment of large sedentary invertebrates and habitat was conducted using a tow-board technique adapted from English *et al.* (1997), with a snorkeller towed at low speed (<2.5 km/hour). This is a slower speed than is generally used for manta transects, and is less than half the normal walking pace of a pedestrian.

Where possible, manta surveys were completed at 12 stations per site. Stations were positioned near land masses on fringing reefs (inner stations), within the lagoon system (middle stations) and in areas most influenced by oceanic conditions (outer stations). Replicate measures within stations (called transects) were conducted at depths between 1 m and <10 m of water (mostly 1.5–6 m), covering broken ground (coral stone and sand) and at the edges of reefs. Transects were not conducted in areas that were too shallow for an outboard-powered boat (<1 m) or adjacent to wave-impacted reef.

Each transect covered a distance of ~300 m (thus the total of six transects covered a linear distance of ~2 km). This distance was calibrated using the odometer function within the trip computer option of a Garmin 76Map® GPS. Waypoints were recorded at the start and end of each transect to an accuracy of ≤10 m. The abundance and size estimations for large sedentary invertebrates were taken within a 2 m swathe of benthos for each transect. Broad-based assessments at each station took approximately one hour to complete (7–8 minutes per transect × 6, plus recording and moving time between transects). Hand tally counters and board-mounted bank counters (three tally units) were used to assist with enumerating common species.

The tow-board surveys differed from traditional manta surveys by utilising a lower speed and concentrating on a smaller swathe on the benthos. The slower speed, reduced swathe and greater length of tows used within PROCFish/C protocols were adopted to maximise efficiency when spotting and identifying cryptic invertebrates, while covering areas that were large enough to make representative measures.

Targeted surveys

Reef- and soft-benthos transect surveys (RBt and SBt), and soft-benthos quadrats (SBq)

To assess the range, abundance, size and condition of invertebrate species and their habitat with greater accuracy at smaller scales, reef- and soft-benthos assessments were conducted within fishing areas and suitable habitat. Reef benthos and soft benthos are not mutually exclusive, in that coral reefs generally have patches of sand, while soft-benthos seagrass areas can be strewn with rubble or contain patches of coral. However, these survey stations (each covering approximately 5000 m^2) were selected in areas representative of the habitat (those generally accessed by fishers, although MPAs were examined on occasion). Six 40 m transects (1 m swathe) were examined per station to record most epi-benthic invertebrate resources and some sea stars and urchin species (as potential indicators of habitat condition). Transects were randomly positioned but laid across environmental gradients where possible (e.g. across reefs and not along reef edges). A single waypoint was recorded for each station (to an accuracy of ≤10 m) and habitat recordings were made for each transect (see Figure A1.3.2 and Appendix 1.3.2).

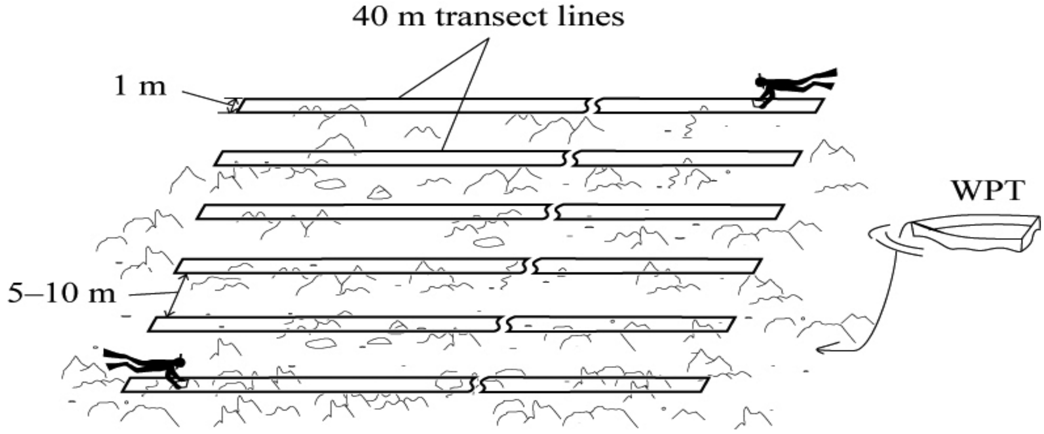


Figure A1.3.2: Example of a reef-benthos transect station (RBt).

To record infaunal resources, quadrats (SBq) were used within a 40 m × 2 m strip transect to measure densities of molluscs (mainly bivalves) in soft-benthos 'shell bed' areas. Four 25 cm^2 quadrats (one quadrat group) were dug to approximately 5–8 cm to retrieve and measure infaunal target species and potential indicator species. Eight randomly spaced quadrat groups were sampled along the 40 m transect line (Figure A1.3.3). A single waypoint and habitat recording was taken for each infaunal station.

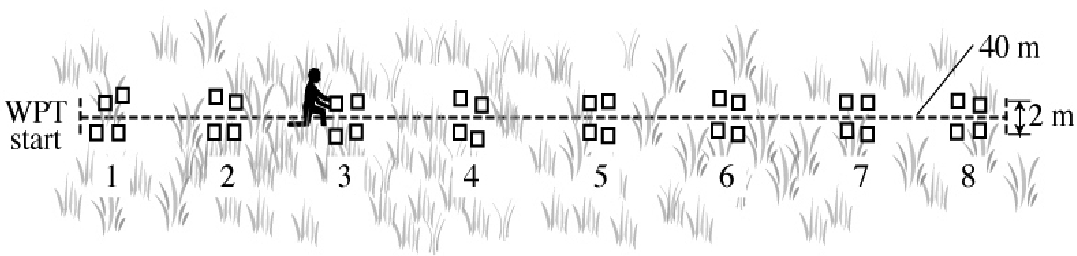


Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

<u>Mother-of-pearl (MOP) or sea cucumber (BdM) fisheries</u>

To assess fisheries such as those for trochus or sea cucumbers, results from broad-scale, reef- and soft-benthos assessments were used. However, other specific surveys were incorporated into the work programme, to more closely target species or species groups not well represented in the primary assessments.

<u>Reef-front searches (RFs and RFs_w)</u>

If swell conditions allowed, three 5-min search periods (30 min total) were conducted along exposed reef edges (RFs) where trochus (*Trochus niloticus*) and surf redfish (*Actinopyga* *mauritiana*) generally aggregate (Figure A1.3.4). Due to the dynamic conditions of the reef front, it was not generally possible to lay transects, but the start and end waypoints of reef-front searches were recorded, and two snorkellers recorded the abundance (generally not size measures) of large sedentary species (concentrating on trochus, surf redfish, gastropods and clams).

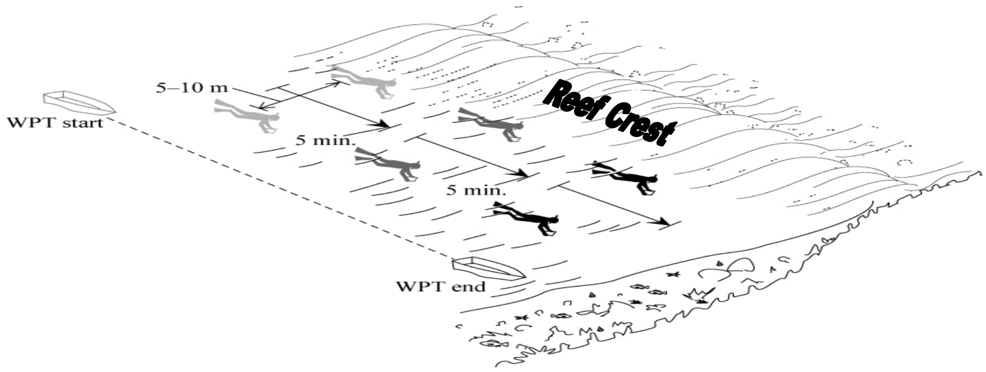


Figure A1.3.4: Reef-front search (RFs) station.

On occasions when it was too dangerous to conduct in-water reef-front searches (due to swell conditions or limited access) and the reeftop was accessible, searches were conducted on foot along the top of the reef front (RFs_w). In this case, two officers walked side by side (5–10 m apart) in the pools and cuts parallel to the reef front. This search was conducted at low tide, as close as was safe to the wave zone. In this style of assessment, reef-front counts of sea cucumbers, gastropod shells, urchins and clams were made during three 5-min search periods (total of 30 minutes search per station).

In the case of *Trochus niloticus*, reef-benthos transects, reef-front searches and local advice (trochus areas identified by local fishers) led us to reef-slope and shoal areas that were surveyed using SCUBA. Initially, searches were undertaken using SCUBA, although SCUBA transects (greater recording accuracy for density) were adopted if trochus were shown to be present at reasonable densities.

Mother-of-pearl search (MOPs)

Initially, two divers (using SCUBA) actively searched for trochus for three 5-min search periods (30 min total). Distance searched was estimated from marked GPS start and end waypoints. If more than three individual shells were found on these searches, the stock was considered dense enough to proceed with the more defined area assessment technique (MOPt).

Mother-of-pearl transects (MOPt)

Also on SCUBA, this method used six 40-m transects (2 m swathe) run perpendicular to the reef edge and not exceeding 15 m in depth (Figure A1.3.5). In most cases the depth ranged between 2 and 6 m, although dives could reach 12 m at some sites where more shallow-water habitat or stocks could not be found. In cases where the reef dropped off steeply, more oblique transect lines were followed. On MOP transect stations, a hip-mounted (or handheld) Chainman® measurement system (thread release) was used to measure out the 40 m. This allowed a hands-free mode of survey and saved time and energy in the often dynamic conditions where *Trochus niloticus* are found.

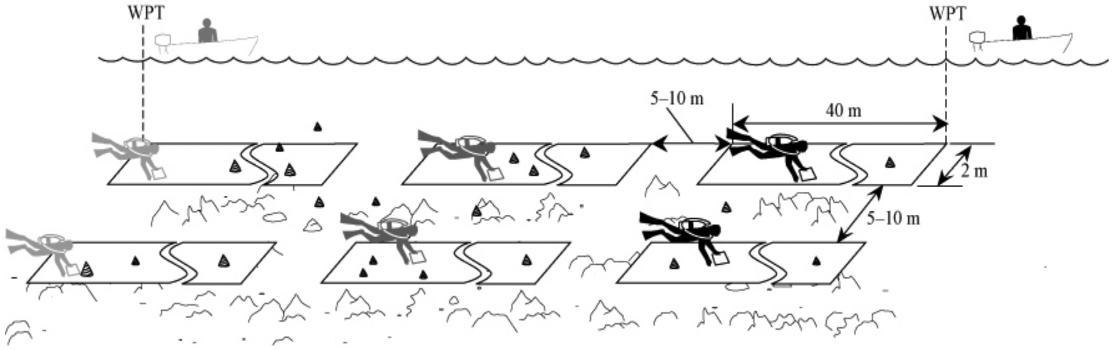


Figure A1.3.5: Mother-of-pearl transect station (MOPt).

Sea cucumber day search (Ds)

When possible, dives to 25–35 m were made to establish if white teatfish (*Holothuria (Microthele) fuscogilva*) populations were present and give an indication of abundance. In these searches two divers recorded the number and sizes of valuable deep-water sea cucumber species within three 5-min search periods (30 min total). This assessment from deep water does not yield sufficient presence/absence data for a very reliable inference on the status (i.e. 'health') of this and other deeper-water species.

Sea cucumber night search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) for sea cucumbers and other echinoderms were conducted (using snorkel) for predominantly nocturnal species (blackfish *Actinopyga miliaris*, *A. lecanora*, and *Stichopus horrens*). Sea cucumbers were collected for three 5-min search periods by two snorkellers (30 min total), and if possible weighed (length and width measures for *A. miliaris* and *A. lecanora* are more dependent on the condition than the age of an individual).

Reporting style

For country site reports, results highlight the presence and distribution of species of interest, and their density at scales that yield a representative picture. Generally speaking, mean densities (average of all records) are presented, although on occasion mean densities for areas of aggregation ('patches') are also given. The later density figure is taken from records (stations or transects, as stated) where the species of interest is present (with an abundance >zero). Presentation of the relative occurrence and densities (without the inclusion of zero records) can be useful when assessing the status of aggregations within some invertebrate stocks.

An example and explanation of the reporting style adopted for invertebrate results follows.

1. The mean density range of *Tridacna* spp. on broad-scale stations (n = 8) was 10–120 per ha.

Density range includes results from all stations. In this case, replicates in each station are added and divided by the number of replicates for that station to give a mean. The lowest and highest station averages (here 10 and 120) are presented for the range. The number in brackets (n = 8) highlights the number of stations examined.

2. The mean density (per ha, ±SE) of all *Tridacna* clam species observed in broad-scale transects (n = 48) was 127.8 ±21.8 (occurrence in 29% of transects).

Mean density is the arithmetic mean, or average of measures across all replicates taken (in this case broad-scale transects). On occasion mean densities are reported for stations or transects where the species of interest is found at an abundance greater than zero. In this case the arithmetic mean would only include stations (or replicates) where the species of interest was found (excluding zero replicates). If this was presented for stations, even stations with a single clam from six transects would be included. (Note: a full breakdown of data is presented in the appendices.)

Written after the mean density figure is a descriptor that highlights variability in the figures used to calculate the mean. Standard error[3] (SE) is used in this example to highlight variability in the records that generated the mean density (SE = (standard deviation of records)/√n). This figure provides an indication of the dispersion of the data when trying to estimate a population mean (the larger the standard error, the greater variation of data points around the mean presented).

Following the variability descriptor is a presence/absence indicator for the total dataset of measures. The presence/absence figure describes the percentage of stations or replicates with a recording >0 in the total dataset; in this case 29% of all transects held *Tridacna* spp., which equated to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* was 12.4 ±1.1 (n = 114).

The number of units used in the calculation is indicated by *n*. In the last case, 114 clams were measured.

[3] In order to derive confidence limits around the mean, a transformation (usually y = log (x+1)) needs to be applied to data, as samples are generally non-normally distributed. Confidence limits of 95% can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3.2 General fauna invertebrate recording sheet with instructions to users

DATE		RECORDER		Pg No	

STATION NAME																		
WPT - WIDTH																		
RELIEF / COMPLEXITY **1–5**																		
OCEAN INFLUENCE **1–5**																		
DEPTH (M)																		
% SOFT SED (M – S – CS)																		
% RUBBLE / BOULDERS																		
% CONSOL RUBBLE / PAVE																		
% CORAL *LIVE*																		
% CORAL *DEAD*																		
SOFT / SPONGE / FUNGIDS																		
ALGAE *CCA*																		
CORALLINE																		
OTHER																		
GRASS																		
EPIPHYTES **1–5** / SILT **1–5**																		
bleaching: % of																		
entered /	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Figure A1.3.6: Sample of the invertebrate fauna survey sheet.

The sheet above (Figure A1.3.6) has been modified to fit on this page (the original has more line space (rows) for entering species data). When recording abundance or length data against species names, columns are used for individual transects or 5-min search replicates. If more space is needed, more than a single column can be used for a single replicate.

A separate sheet is used by a recorder in the boat to note information from handheld GPS equipment. In addition to the positional information, this boat sheet has space for manta transect distance (from GPS odometer function) and for sketches and comments.

1.3.3 Habitat section of invertebrate recording sheet with instructions to users

Figure A1.3.7 depicts the habitat part of the form used during invertebrate surveys; it is split into seven broad categories.

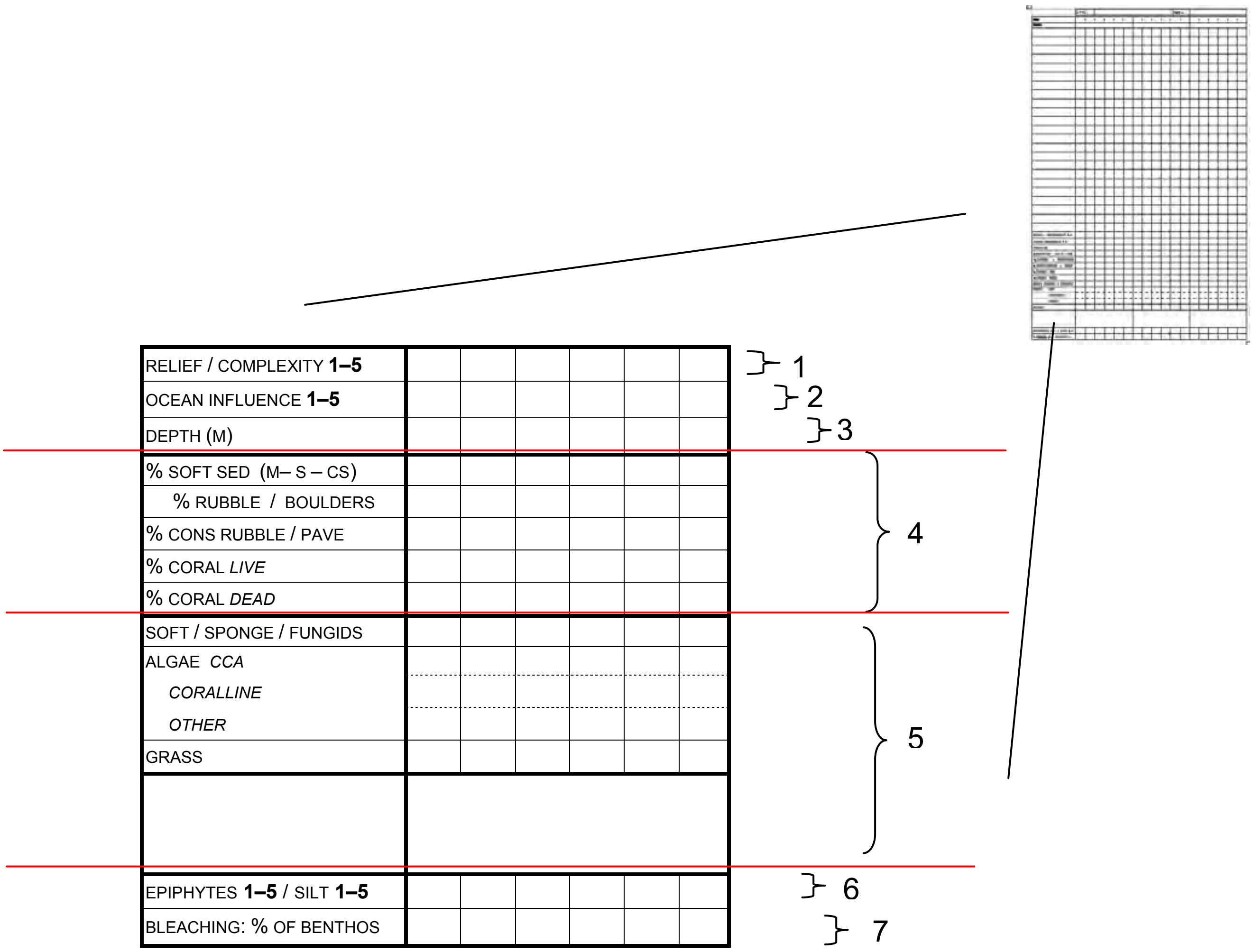


Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

Relief and complexity (section 1 of form)

Each is on a scale of 1 to 5. If a record is written as 1/5, relief is 1 and complexity is 5, with the following explanation.

Relief describes average height variation for hard (and soft) benthos transects:

1 = flat (to ankle height)
2 = ankle up to knee height
3 = knee to hip height
4 = hip to shoulder/head height
5 = over head height

Complexity describes average surface variation for substrates (relative to places for animals to find shelter) for hard (and soft) benthos transects:

1 = smooth – no holes or irregularities in substrate
2 = some complexity to the surfaces but generally little

3 = generally complex surface structure
4 = strong complexity in surface structure, with cracks, spaces, holes, etc.
5 = very complex surfaces with lots of spaces, nooks, crannies, under-hangs and caves

Ocean influence (section 2 of form)

1 = riverine, or land-influenced seawater with lots of allochthonous input
2 = seawater with some land influence
3 = ocean and land-influenced seawater
4 = water mostly influenced by oceanic water
5 = oceanic water without land influence

Depth (section 3 of form)

Average depth in metres

Substrate – bird's-eye view of what's there (section 4 of form)

All of section 4 must make up 100%. Percentage substrate is estimated in units of 5% so, e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Soft substrate	Soft sediment – mud
Soft substrate	Soft sediment – mud and sand
Soft substrate	Soft sediment – sand
Soft substrate	Soft sediment – coarse sand
Hard substrate	Rubble
Hard substrate	Boulders
Hard substrate	Consolidated rubble
Hard substrate	Pavement
Hard substrate	Coral live
Hard substrate	Coral dead

Mud, sand, coarse sand: The sand is not sieved – it is estimated visually and manually. Surveyors can use the 'drop test', where sand drops through the water column and mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement, etc. are not listed as soft substrate unless the layer is significant (>a couple of cm).

Rubble is small (<25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. AIMS' definition is very similar to that for Reefcheck (found on the 'C-nav' interactive CD): 'pieces of coral (reef) between 0.5 and 15 cm. If smaller, it is sand; if larger, then rock or whatever organism is growing upon it'.

Boulders are detached, big pieces (>30 cm) of stone, coral stone and limestone debris.

Consolidated rubble is attached, cemented pieces of coral stone and limestone debris. We tend to use 'rubble' for pieces or piles loose in the sediment of seagrass, etc., and 'consolidated rubble' for areas that are not flat pavement but concreted rubble on reeftops and cemented talus slopes.

Appendix 1: Survey methods
Invertebrates

Pavement is solid, substantial, fixed, flat stone (generally limestone) benthos.

Coral live is any live hard coral.

Coral dead is coral that is recognisable as coral even if it is long dead. Note that long-dead and *eroded* coral that is found in flat pavements is called ‘pavement’ and when it is found in loose pieces or blocks it is termed ‘rubble’ or ‘boulders’ (depending on size).

Cover – what is on top of the substrate (section 5 of form)

This cannot exceed 100%, but can be anything from 0 to 100%. Surveyors give scores in blocks of 5%, so e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Cover	Soft coral
Cover	Sponge
Cover	Fungids
Cover	Crustose-nongeniculate coralline algae
Cover	Coralline algae
Cover	Other (algae like sargassum, caulerpa and padina)
Cover	Seagrass

Soft coral is all soft corals but not Zoanthids or anemones.

Sponge includes half-buried sponges in seagrass beds – only sections seen on the surface are noted.

Fungids are fungids.

Crustose – nongeniculate coralline algae are pink rock. Crustose or nongeniculate coralline algae (NCA) are red algae that deposit calcium carbonate in their cell walls. Generally they are members of the division Rhodophyta.

Coralline algae – halimeda are red coralline algae (often seen in balls – *Galaxaura*). (Note: AIMS lists *halimeda* and other coralline algae as macro algae along with fleshy algae not having $CaCo_3$ deposits.)

Other algae include fleshy algae such as *Turbinaria*, *Padina* and *Dictyota*. Surveyors describe coverage by taking a bird’s-eye view of what is covered, not by delineating the spatial area of the algae colony within the transect (i.e. differences in very low or high density are accounted for). The large space on the form is used to write species information if known.

Seagrass includes seagrass such as *Halodule*, *Thalassia*, *Halophila* and *Syringodium*. Surveyors note types by species if possible or by structure (i.e. flat versus reed grass), and describe coverage by taking a bird’s-eye view of what benthos is covered, not by delineating the spatial area of the grass meadow within the transect (i.e. differences in very low or high density are accounted for).

Cover continued – epiphytes and silt (section 6 of form)

Epiphytes 1–5 grade are mainly turf algae – turf that grows on hard and soft substrates, but also on algae and grasses. The growth is usually fine-stranded filamentous algae that have few noticeable distinguishing features (more like fuzz).

1 = none
2 = small areas or light coverage
3 = patchy, medium coverage
4 = large areas or heavier coverage
5 = very strong coverage, long and thick almost choking epiphytes – normally including strands of blue-green algae as well

Silt 1–5 grade (or a similar fine-structured material sometimes termed 'marine snow') consists of fine particles that slowly settle out from the water but are easily re-suspended. When re-suspended, silt tends to make the water murky and does not settle quickly like sand does. Sand particles are not silt and should not be included here when seen on outer-reef platforms that are wave affected.

1 = clear surfaces
2 = little silt seen
3 = medium amount of silt-covered surfaces
4 = large areas covered in silt
5 = surfaces heavily covered in silt

Bleaching (section 7 of form)

The percentage of bleached live coral is recorded in numbers from 1 to 100% (Not 5% blocks). This is the percentage of benthos that is dying hard coral (just-bleached) or very recently dead hard coral showing obvious signs of recent bleaching.

APPENDIX 2: SOCIOECONOMIC SURVEY DATA

2.1 Nggela socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat – Nggela
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Malole	Belonidae	*Strongylura* spp.	216	23.3
Mamula	Carangidae	*Carangoides* spp.	177	19.1
Kepo	Clupeidae	*Herklotsichthys quadrimaculatus*	120	13.0
Mangatata	Lethrinidae	*Gymnocranius* spp.	78	8.4
Bobona	Acanthuridae	*Ctenochaetus striatus*, *Ctenochaetus* spp.	78	8.4
Mamanga	Carangidae	*Selar boops*	46	5.0
Sivare	Serranidae	*Cephalopholis* spp.	36	3.8
Kavaga	Acanthuridae	*Naso annulatus*	36	3.8
Ango ni horara	Lutjanidae	*Macolor niger*	36	3.8
Tala	Holocentridae	*Sargocentron spiniferum*	36	3.8
Taburara	Serranidae	*Plectropomus* spp.	36	3.8
Karamalabo	Serranidae	*Plectropomus* spp.	36	3.8
Total:			**928**	**100.1**
Sheltered coastal reef & lagoon				
Sori	Holocentridae	*Myripristis* spp.	889	9.2
Sivare	Serranidae	*Cephalopholis* spp.	849	8.8
Kusele	Serranidae	*Epinephelus* spp., *Epinephelus corallicola*	673	7.0
Mara	Scaridae	*Scarus* spp.	389	4.0
Kara	Carangidae	*Carangoides* spp.	345	3.6
Atukere	Scombridae	*Gymnosarda unicolor*	320	3.3
Kura	Acanthuridae	*Acanthurus lineatus*	317	3.3
Agoago	Haemulidae	*Plectorhinchus* spp.	308	3.2
Kavaga	Acanthuridae	*Naso annulatus*	299	3.1
Pehu	Haemulidae	*Plectorhinchus gibbosus*	292	3.0
Mihu	Lutjanidae	*Lutjanus* spp.	262	2.7
Kepo	Clupeidae	*Herklotsichthys quadrimaculatus*	210	2.2
Pisi	Serranidae	*Epinephelus* spp.	178	1.9
Iga raurau	Labridae	*Bodianus diana*	155	1.6
Kaekale	Siganidae	*Siganus argenteus*	153	1.6
Cororo	Serranidae	*Cromileptes* spp.	142	1.5
Aniri	Scombridae	*Scomberomorus commerson*	142	1.5
Chori	Holocentridae	*Myripristis vittata*	142	1.5
Bubu	Balistidae	*Melichthys* spp.	142	1.5
Asu	Lethrinidae	*Gnathodentex aureolineatus*	142	1.5
Igamea	Haemulidae	*Plectorhinchus gibbosus*	142	1.5
Kome	Haemulidae	*Plectorhinchus* spp.	138	1.4
Ango ni horara	Lutjanidae	*Macolor niger*	133	1.4
Uvoro	Lutjanidae	*Lutjanus* spp.	131	1.4
Sivari	Serranidae	*Variola albimarginata*	124	1.3

2.1.1 Annual catch (kg) of fish groups per habitat – Nggela (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon (continued)				
Mumuku	Balistidae	*Balistapus undulatus*	113	1.2
Araoke	Lethrinidae	*Monotaxis grandoculis*	107	1.1
Alulu	Carangidae	*Caranx* spp.	107	1.1
Tala	Holocentridae	*Sargocentron spiniferum*	106	1.1
Kokoru	Lutjanidae	*Lutjanus bohar*	99	1.0
Ngingi	Mullidae	*Parupeneus* spp.	97	1.0
Ango	Lutjanidae	*Lutjanus rivulatus*	95	1.0
Mangatata	Lethrinidae	*Gymnocranius* spp.	94	1.0
Gigi	Lutjanidae	*Lutjanus* spp.	88	0.9
Kulipatu	Serranidae	*Epinephelus polyphekadion*	88	0.9
Esa	Lethrinidae	*Lethrinus miniatus*	87	0.9
Buma	Carangidae	*Selar crumenophthalmus*	85	0.9
Dolatoto	Nemipteridae	*Scolopsis* spp.	85	0.9
Ghohi	Sphyraenidae	*Sphyraena* spp.	85	0.9
Dudu	Siganidae	*Siganus punctatus*	85	0.9
Maroho	Carangidae	*Elagatis bipinnulata*	71	0.7
Ririhu			71	0.7
Davivula	Lethrinidae	*Lethrinus* spp., *Monotaxis grandoculis*	71	0.7
Leoleko	Kyphosidae	*Kyphosus vaigiensis*	71	0.7
Talia	Labridae	*Cheilinus* spp.	71	0.7
Kimasi	Lutjanidae	*Lutjanus* spp.	71	0.7
Suru	Haemulidae	*Plectorhinchus celebicus*	71	0.7
Vudere	Lutjanidae	*Lutjanus fulvus*	71	0.7
Igusasa	Caesionidae	*Caesio* spp.	71	0.7
Koere	Acanthuridae	*Acanthurus lineatus*	71	0.7
Mamanga	Carangidae	*Selar boops*	64	0.7
Vurusige	Lutjanidae	*Lutjanus semicinctus*	56	0.6
Mamula	Carangidae	*Carangoides* spp.	53	0.6
Sigo	Pomacanthidae	*Pygoplites diacanthus*	51	0.5
Igamereseini	Lethrinidae	*Gymnocranius grandoculis*	47	0.5
Kavala	Carangidae	*Scomberoides tala*	47	0.5
Taburara	Serranidae	*Plectropomus* spp.	47	0.5
Kuva	Serranidae	*Cephalopholis argus*	47	0.5
Barubaru	Balistidae	*Balistoides* spp.	36	0.4
Huru	Lethrinidae	*Lethrinus harak*	24	0.2
Kura korode	Acanthuridae	*Acanthurus lineatus*	16	0.2
Total:			**9642**	**100.0**
Lagoon				
Ulele	Serranidae	*Variola* spp.	128	32.1
Tarasi	Acanthuridae	*Acanthurus* spp.	128	32.1
Ramusi	Lethrinidae	*Lethrinus* spp.	71	17.9
Mu	Siganidae	*Siganus doliatus*	71	17.9
Total:			**398**	**100.0**

2.1.1 Annual catch (kg) of fish groups per habitat – Nggela (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon & outer reef				
Anate	Mugilidae	*Crenimugil crenilabis*	166	11.9
Ghuhe	Mullidae	*Parupeneus* spp.	119	8.5
Asu	Lethrinidae	*Gnathodentex aureolineatus*	113	8.1
Atu	Scombridae	*Thunnus orientalis*	85	6.1
Cororo	Serranidae	*Cromileptes* spp.	85	6.1
Davoro	Serranidae	*Cephalopholis* spp.	85	6.1
Alinga	Carangidae	*Caranx* spp.	71	5.1
Ededa	Sphyraenidae	*Sphyraena* spp.	71	5.1
Chori	Holocentridae	*Myripristis vittata*	71	5.1
Igamea	Haemulidae	*Plectorhinchus gibbosus*	71	5.1
Araoke	Lethrinidae	*Monotaxis grandoculis*	71	5.1
Ango	Lutjanidae	*Lutjanus rivulatus*	71	5.1
Ghohi	Sphyraenidae	*Sphyraena* spp.	71	5.1
Humihumi	Mullidae	*Parupeneus* spp.	71	5.1
Huruhiu	Sphyraenidae	*Sphyraena* spp.	56	4.1
Karapata	Lethrinidae	*Lethrinus* spp.	56	4.1
Heheuku	Lutjanidae	*Lutjanus* spp.	56	4.1
Total:			**1390**	**100.0**
Outer reef				
Kara	Carangidae	*Carangoides* spp.	*658*	*11.9*
Kusele	Serranidae	*Epinephelus* spp., *Epinephelus corallicola*	*606*	*11.0*
Sivare	Serranidae	*Cephalopholis* spp.	*555*	*10.0*
Sori	Holocentridae	*Myripristis* spp.	*526*	*9.5*
Maroho	Carangidae	*Elagatis bipinnulata*	*324*	*5.9*
Uvoro	Lutjanidae	*Lutjanus* spp.	*245*	*4.4*
Agoago	Haemulidae	*Plectorhinchus* spp.	*220*	*4.0*
Atu	Scombridae	*Thunnus orientalis*	*198*	*3.6*
Mamula	Carangidae	*Carangoides* spp.	*196*	*3.6*
Huru	Lethrinidae	*Lethrinus harak*	*191*	*3.5*
Ramusi	Lethrinidae	*Lethrinus* spp.	*163*	*3.0*
Mumuku	Balistidae	*Balistapus undulatus*	*151*	*2.7*
Sinu	Scombridae	*Thunnus* spp.	*144*	*2.6*
Pakata	Acanthuridae	*Naso* spp.	*128*	*2.3*
Ririhu			*128*	*2.3*
Bonito	Scombridae	*Sarda* spp.	*113*	*2.0*
Igamea	Haemulidae	*Plectorhinchus gibbosus*	*111*	*2.0*
Esa	Lethrinidae	*Lethrinus miniatus*	*104*	*1.9*
Livogau	Lutjanidae	*Lutjanus vitta*	*104*	*1.9*
Pisi	Serranidae	*Epinephelus* spp.	*91*	*1.6*
Cororo	Serranidae	*Cromileptes* spp.	*71*	*1.3*
Pepata	Lethrinidae	*Lethrinus genivittatus*	*71*	*1.3*
Igamereseini	Lethrinidae	*Gymnocranius grandoculis*	*71*	*1.3*
Tala	Holocentridae	*Sargocentron spiniferum*	*53*	*1.0*
Marawa	Scaridae	*Scarus rubroviolaceus*	*53*	*1.0*
Kepo	Clupeidae	*Herklotsichthys quadrimaculatus*	*52*	*0.9*

2.1.1 Annual catch (kg) of fish groups per habitat – Nggela (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef (continued)				
Pipirikoho	Haemulidae	*Plectorhinchus* spp.	*47*	*0.9*
Malole	Belonidae	*Strongylura* spp.	*42*	*0.8*
Mihu	Lutjanidae	*Lutjanus* spp.	*36*	*0.6*
Makoto	Balistidae	*Balistapus* spp.	*36*	*0.6*
Puri	Carangidae	*Selaroides leptolepis*	*24*	*0.4*
Pehu	Haemulidae	*Plectorhinchus gibbosus*	*18*	*0.3*
Total:			**5531**	**100.0**
Outer reef & passage				
Alinga	Carangidae	*Caranx* spp.	223	50.0
Ededa	Sphyraenidae	*Sphyraena* spp.	223	50.0
Total:			**447**	**0.0**

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Nggela

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Bêche-de-mer	Pou	*Holothuria* spp.	100.0
	Ime		
Bêche-de-mer & other	Pou	*Holothuria* spp.	94.7
	Vagoda	*Tridacna maxima*	5.3
Bêche-de-mer & mother-of-pearl & other	Pou	*Holothuria* spp.	57.7
	Lala	*Trochus niloticus*	38.5
	Konola	*Tripneustes gratilla*	3.8
Lobster	Hikama	*Panulirus* spp.	95.6
	Kiki	*Tridacna* spp.	4.4
Mangrove	Keu	*Tridacna crocea*	77.2
	Ihu	*Pinna bicolor*	10.7
	Kuta		4.6
	Konola	*Tripneustes gratilla*	2.3
	Arimango	*Scylla serrata*	2.1
	Sura	*Strombus luhuanus*	1.9
	Boru- dorili	*Terebra* spp.	1.1
Mangrove & other	Keu	*Tridacna crocea*	100.0
Other	Vagoda	*Tridacna maxima*	34.6
	Lala	*Trochus niloticus*	22.9
	Hio	*Tridacna gigas*	17.2
	Kiki	*Tridacna* spp.	14.3
	Arimango	*Scylla serrata*	10.0
	Tutu	*Anadara* spp.	1.0
Reeftop	Ilo	*Hyotissa* spp.	30.5
	Sura	*Strombus luhuanus*	30.5
	Konola	*Tripneustes gratilla*	15.3
	Ihu	*Pinna bicolor*	15.3
	Kahiha	*Thais* spp.	4.6
	Tutu	*Anadara* spp.	2.0
	Sagu	*Nerita* spp.	1.9

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Nggela (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Reeftop & lobster & other	Lala	*Trochus niloticus*	42.1
	Hikama	*Panulirus* spp.	42.1
	Pukumau	*Tridacna maxima*	10.5
	Sura	*Strombus luhuanus*	5.3
Reeftop & other	Vagoda	*Tridacna maxima*	29.8
	Ihu	*Pinna bicolor*	14.3
	Sipiu	*Octopus* spp.	8.2
	Lingamu	*Scylla serrata*	8.1
	Pukumau	*Tridacna maxima*	7.4
	Mapa	*Parribacus antarcticus*	6.2
	Kiki	*Tridacna* spp.	5.6
	Sura	*Strombus luhuanus*	5.1
	Meno	*Tridacna maxima*	4.1
	Kaluha	*Donax cuneatus*	2.5
	Lambugai	*Cerithium nodulosum*	2.0
	Hikama	*Panulirus* spp.	1.2
	Konola	*Tripneustes gratilla*	1.2
	Hihi	*Tridacna derasa*	1.0
	Ngau	*Lambis crocata*	0.8
	Paupasua	*Thais* spp.	0.5
	Mera	*Strombus* spp.	0.5
	Karogo	*Trochus niloticus*	0.5
	Katou	*Cardisoma* spp.	0.3
	Sagu	*Nerita* spp.	0.2
	Ringasa	*Lambis lambis*	0.2
	Keke	*Anadara* spp.	0.1
	Tutu	*Anadara* spp.	0.1
	Kwasi	*Anadara* spp.	0.0
Reeftop & mother-of-pearl	Ghuhum	*Tridacna maxima*	49.6
	Kakau	*Carpilius maculatus*	27.8
	Gharumu	*Cardisoma* spp.	22.6
Reeftop & mother-of-pearl & other	Lala	*Trochus niloticus*	25.5
	Pukumau	*Tridacna maxima*	15.3
	Ura	*Panulirus* spp.	11.7
	Lingamu	*Scylla serrata*	11.2
	Mapa	*Parribacus antarcticus*	10.9
	Konola	*Tripneustes gratilla*	10.2
	Boru- dorili	*Terebra* spp.	6.6
	Kokonola	*Tripneustes gratilla*	5.8
	Vagoda	*Tridacna maxima*	2.7
Sand	Kakautia	*Cardisoma* spp.	100.0
Sand & reeftop	Kiki	*Tridacna* spp.	23.2
	Ura	*Panulirus* spp.	18.8
	Vagoda	*Tridacna maxima*	13.6
	Sura	*Strombus luhuanus*	11.4
	Keu	*Tridacna crocea*	9.1
	Konola	*Tripneustes gratilla*	7.4
	Hato	*Trochus niloticus*	3.9

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Nggela (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Sand & reeftop (continued)	Kokonola	*Tripneustes gratilla*	2.3
	Ngau	*Lambis crocata*	2.1
	Kakau	*Carpilius maculatus*	1.5
	Sagu	*Nerita* spp.	1.4
	Gau	*Lambis lambis*	1.3
	Tutu	*Anadara* spp.	1.0
	Sipiu	*Octopus* spp.	1.0
	Kahiha	*Thais* spp.	0.8
	Lili	*Turbo* spp.	0.7
	Keke	*Anadara* spp.	0.3
	Ununus	*Strombus* spp.	0.2
	Paupasua	*Thais* spp.	0.1
	Papaura		
Sand & reeftop & other	Ihu	*Pinna bicolor*	33.3
	Vagoda	*Tridacna maxima*	19.5
	Konola	*Tripneustes gratilla*	6.7
	Sura	*Strombus luhuanus*	6.4
	Ura	*Panulirus* spp.	5.9
	Lala	*Trochus niloticus*	5.6
	Hikama	*Panulirus* spp.	3.4
	Tubala	*Cardisoma* spp.	3.3
	Sipiu	*Octopus* spp.	2.3
	Kokonola	*Tripneustes gratilla*	2.2
	Lingamu	*Scylla serrata*	2.1
	Kiki	*Tridacna* spp.	2.0
	Bikoho	*Trochus niloticus*	2.0
	Ghuhum	*Tridacna maxima*	1.7
	Aro	*Pinctada* spp.	1.5
	Sagu	*Nerita* spp.	1.0
	Ngau	*Lambis crocata*	0.6
	Boru	*Terebralia palustris*	0.2
	Boru- dorili	*Terebra* spp.	0.1
	Lili	*Turbo* spp.	0.1
	Kaluha	*Donax cuneatus*	0.1
	Keke	*Anadara* spp.	0.1
	Nara	*Lambis lambis*	0.1
	Papaura		
Sand & reeftop & mother-of-pearl & other	Vagoda	*Tridacna maxima*	45.1
	Meno	*Tridacna maxima*	29.4
	Hato	*Trochus niloticus*	15.7
	Kokonola	*Tripneustes gratilla*	9.8
Soft benthos	Kunuga	*Tridacna crocea*	88.8
	Kwasi	*Anadara* spp.	11.2
Soft benthos & mangrove	Keu	*Tridacna crocea*	79.3
	Kuta		14.0
	Arimango	*Scylla serrata*	1.7
	Sura	*Strombus luhuanus*	1.4
	Ihu	*Pinna bicolor*	1.0

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Nggela (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & mangrove	Boru- dorili	*Terebra* spp.	0.8
	Tubala	*Cardisoma* spp.	0.7
	Ropi	*Terebralia palustris*	0.4
	Sipiu	*Octopus* spp.	0.2
	Sagu	*Nerita* spp.	0.2
	Konola	*Tripneustes gratilla*	0.2
	Roga	*Saccostrea* spp.	0.1
	Tutu	*Anadara* spp.	0.0
Soft benthos & reeftop	Pou	*Holothuria* spp.	70.0
	Meno	*Tridacna maxima*	17.5
	Keu	*Tridacna crocea*	12.5
Mother-of-pearl	Lala	*Trochus niloticus*	100.0
Mother-of-pearl & lobster & other	Lala	*Trochus niloticus*	56.1
	Vagoda	*Tridacna maxima*	31.6
	Kakau	*Carpilius maculatus*	12.3
Mother-of-pearl & other	Pou	*Holothuria* spp.	45.2
	Vagoda	*Tridacna maxima*	23.7
	Lala	*Trochus niloticus*	23.1
	Hikama	*Panulirus* spp.	3.4
	Kakau	*Carpilius maculatus*	2.7
	Hihi	*Tridacna derasa*	0.9
	Hato	*Trochus niloticus*	0.7
	Pisiu	*Octopus* spp.	0.3
	Kaluha	*Donax cuneatus*	0.0

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Nggela

Vernacular name	Scientific name	Size class	% of total catch (weight)
Arimango	*Scylla serrata*	10–16 cm	18.5
		12–14 cm	18.5
		12–16 cm	33.9
		14–16 cm	6.2
		14–18 cm	18.3
		16–18 cm	4.6
Aro	*Pinctada* spp.	06–08 cm	100.0
Bikoho	*Trochus niloticus*	06–08 cm	100.0
Boru	*Terebralia palustris*	08–10 cm	100.0
Boru- dorili	*Terebra* spp.	03–05 cm	4.6
		03–06 cm	19.8
		04–06 cm	19.7
		06–08 cm	56.0
Gau	*Lambis lambis*	06–12 cm	8.4
		10–12 cm	18.3
		10–14 cm	73.3
Gharumu	*Cardisoma* spp.	10–12 cm	100.0
Ghuhum	*Tridacna maxima*	10–12 cm	41.7
		12–14 cm	58.3

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Nggela (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Hato	*Trochus niloticus*	08–12 cm	60.6
		10–12 cm	39.4
Hihi	*Tridacna derasa*	08–10 cm	50.0
		12–14 cm	50.0
Hikama	*Panulirus* spp.	06–08 cm	19.4
		10–12 cm	16.9
		18–22 cm	57.9
		20v24 cm	1.9
		20–25 cm	3.9
Hio	*Tridacna gigas*	04–08 cm	100.0
Ihu	*Pinna bicolor*	03–04 cm	60.4
		03–05 cm	8.0
		04–06 cm	3.2
		04–08 cm	3.7
		05–08 cm	7.0
		06-08 cm	14.1
		06–10 cm	2.0
		08–10 cm	1.5
Ilo	*Hyotissa* spp.	06–10 cm	100.0
Kahiha	*Thais* spp.	03–04 cm	40.0
		04–06 cm	60.0
Kakau	*Carpilius maculatus*	08–10 cm	54.6
		08–14 cm	12.1
		10–12 cm	33.2
Kakautia	*Cardisoma* spp.	08–14 cm	100.0
Kaluha	*Donax cuneatus*	03–04 cm	46.8
		03–05 cm	46.8
		06–08 cm	6.3
Karogo	*Trochus niloticus*	10–14 cm	100.0
Katou	*Cardisoma* spp.	12–14 cm	100.0
Keke	*Anadara* spp.	06 cm	100.0
Keu	*Tridacna crocea*	04–08 cm	0.7
		06–08 cm	2.1
		06–10 cm	53.4
		06–12 cm	34.1
		08–12 cm	4.4
		10–12 cm	1.0
		12–16 cm	4.3
Kiki	*Tridacna* spp.	08–14 cm	8.3
		10–14 cm	11.6
		12–14 cm	22.0
		12–16 cm	58.2
Kokonola	*Tripneustes gratilla*	06–08 cm	41.1
		06–12 cm	36.5
		08–10 cm	11.0
		08–12 cm	11.4

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Nggela (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Konola	*Tripneustes gratilla*	01 cm	81.9
		06–10 cm	12.7
		10–12 cm	5.4
Kunuga	*Tridacna crocea*	06–10 cm	100.0
Kuta		03–05 cm	27.1
		03–06 cm	8.1
		04–06 cm	28.5
		04–08 cm	10.9
		06–08 cm	9.1
		06–10 cm	16.3
Kwasi	*Anadara* spp.	06 cm	100.0
Lala	*Trochus niloticus*	08–12 cm	54.9
		08–14 cm	41.3
		12–14 cm	3.8
Lambugai	*Cerithium nodulosum*	05–08 cm	100.0
Lili	*Turbo* spp.	04–06 cm	29.4
		04–08 cm	70.6
Lingamu	*Scylla serrata*	06–12 cm	29.0
		10–12 cm	16.1
		10–14 cm	19.4
		12–14 cm	19.4
		14–16 cm	16.1
Mapa	*Parribacus antarcticus*	12–14 cm	20.0
		12–16 cm	30.0
		14–16 cm	50.0
Meno	*Tridacna maxima*	12–14 cm	26.9
		12–16 cm	31.3
		14–16 cm	41.8
Mera	*Strombus* spp.	06 cm	100.0
Nara	*Lambis lambis*	08–10 cm	100.0
Ngau	*Lambis crocata*	04–08 cm	18.5
		06–08 cm	18.5
		06–10 cm	14.8
		08–10 cm	7.4
		08–12 cm	5.9
		08–14 cm	5.5
		10–14 cm	5.2
		12–14 cm	24.4
Papaura		01 cm	
		03–05 cm	
Paupasua	*Thais* spp.	03–05 cm	93.3
		04–06 cm	6.7
Pisiu	*Octopus* spp.	12–14 cm	100.0
Pou	*Holothuria* spp.	08–12 cm	57.4
		08–14 cm	42.6
Pukumau	*Tridacna maxima*	12–16 cm	48.8
		14–18 cm	51.2
Ringasa	*Lambis lambis*	08–12 cm	100.0

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Nggela (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Roga	*Saccostrea* spp.	04–08 cm	100.0
Ropi	*Terebralia palustris*	04–06 cm	100.0
Sagu	*Nerita* spp.	03–04 cm	70.1
		03–05 cm	23.4
		03–06 cm	5.8
		10–12 cm	0.3
		10–14 cm	0.4
Sipiu	*Octopus* spp.	10–12 cm	6.8
		12–14 cm	40.7
		12–16 cm	52.5
Sura	*Strombus luhuanus*	03–04 cm	23.2
		03–05 cm	28.5
		03–06 cm	5.2
		04–06 cm	28.4
		05–06 cm	0.7
		06 cm	14.2
Tubala	*Cardisoma* spp.	08–14 cm	33.3
		12–14 cm	66.7
Tutu	*Anadara* spp.	04–06 cm	17.2
		06 cm	82.8
Ununus	*Strombus* spp.	06 cm	100.0
Ura	*Panulirus* spp.	08–10 cm	60.0
		08–12 cm	40.0
Vagoda	*Tridacna maxima*	06–14 cm	2.7
		08–12 cm	1.8
		10–12 cm	4.2
		10–14 cm	2.7
		10–16 cm	35.7
		12–14 cm	19.9
		12–16 cm	24.6
		13–16 cm	8.5

2.2 Marau socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat – Marau
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Marihu	Lutjanidae	*Lutjanus gibbus*	186	13.5
Suru	Haemulidae	*Plectorhinchus celebicus*	140	10.1
Merasau	Pomacentridae	*Amphiprion clarkii*	140	10.1
Rakui			140	10.1
Buma	Carangidae	*Selar crumenophthalmus*	140	10.1
Apisihata	Holocentridae	*Myripristis adusta*	101	7.3
Agoago	Haemulidae	*Plectorhinchus* spp.	93	6.7
Porapora	Labridae	*Cheilinus undulatus*	93	6.7
Puri	Carangidae	*Selaroides leptolepis*	70	5.1
Bubu	Balistidae	*Melichthys* spp.	70	5.1
Karikari	Mugilidae	*Mugil* spp.	70	5.1
Uku	Balistidae, Carangidae	*Caranx* spp., *Rhinecanthus verrucosus*	47	3.4
Arupara	Siganidae	*Siganus lineatus*	47	3.4
Puripuri	Holocentridae	*Myripristis* spp.	47	3.4
Total:			**1381**	**100.0**
Sheltered coastal reef & lagoon				
Marihu	Lutjanidae	*Lutjanus gibbus*	2254	11.6
Suru	Haemulidae	*Plectorhinchus celebicus*	1262	6.5
Urahu	Serranidae	*Epinephelus* spp.	1156	6.0
Mara	Scaridae	*Scarus* spp.	832	4.3
Merasau	Pomacentridae	*Amphiprion clarkii*	696	3.6
Pakata	Acanthuridae	*Naso* spp.	677	3.5
Rakui			669	3.4
Buma	Carangidae	*Selar crumenophthalmus*	636	3.3
Papaere	Lethrinidae	*Lethrinus* spp.	498	2.6
Puri	Carangidae	*Selaroides leptolepis*	493	2.5
Korosa	Serranidae	*Cephalopholis* spp.	461	2.4
Maua	Scaridae	*Scarus ghobban*	449	2.3
Usiusi	Acanthuridae	*Naso* spp.	428	2.2
Ririhu			398	2.1
Mu	Siganidae	*Siganus doliatus*	396	2.0
Paumatana	Scaridae	*Scarus rubroviolaceus*	388	2.0
Marogo	Lutjanidae	*Lutjanus adetii*	381	2.0
Agoago	Haemulidae	*Plectorhinchus* spp.	381	2.0
Mapote	Carangidae	*Atule mate*	335	1.7
Pasahu	Carangidae	*Caranx* spp.	335	1.7
Anate	Mugilidae	*Crenimugil crenilabis*	333	1.7
Korakora	Mugilidae	*Valamugil* spp.	309	1.6
Osanga	Lethrinidae	*Lethrinus* spp.	309	1.6
Matasi	Mullidae	*Parupeneus* spp.	303	1.6
Kimasi	Lutjanidae	*Lutjanus* spp.	298	1.5
Reto	Scombridae	*Euthynnus* spp.	293	1.5
Asu	Lethrinidae	*Gnathodentex aureolineatus*	291	1.5
Apisihata	Holocentridae	*Myripristis adusta*	251	1.3

2.2.1 Annual catch (kg) of fish groups per habitat – Marau (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon (continued)				
Porapora	Labridae	*Cheilinus undulatus*	247	1.3
Mawauri	Acanthuridae	*Naso unicornis*	245	1.3
Marawa	Scaridae	*Scarus rubroviolaceus*	196	1.0
Pupu	Balistidae	*Abalistes stellaris*	182	0.9
Paa	Acanthuridae	*Acanthurus* spp.	178	0.9
Kawauri			175	0.9
Uku	Balistidae, Carangidae	*Caranx* spp., *Rhinecanthus verrucosus*	163	0.8
Puripuri	Holocentridae	*Myripristis* spp.	154	0.8
Sori	Holocentridae	*Myripristis* spp.	151	0.8
Ihana humihumi	Mullidae	*Upeneus* spp.	151	0.8
Alulu	Carangidae	*Caranx* spp.	144	0.7
Araoke	Lethrinidae	*Monotaxis grandoculis*	128	0.7
Karikari	Mugilidae	*Mugil* spp.	120	0.6
Mihu	Lutjanidae	*Lutjanus* spp.	109	0.6
Korusisi	Lutjanidae	*Lutjanus sebae*	105	0.5
Kusele	Serranidae	*Epinephelus* spp., *Epinephelus corallicola*	105	0.5
Tatavarao	Acanthuridae	*Naso lituratus*	105	0.5
Rauniponi	Haemulidae	*Plectorhinchus lineatus*, *Plectorhinchus vittatus*	91	0.5
Langolango	Lutjanidae	*Lutjanus* spp.	81	0.4
Kama kalua	Labridae	*Halichoeres chloropterus*	76	0.4
Paere	Lethrinidae	*Lethrinus genivittatus*	70	0.4
Arupara	Siganidae	*Siganus lineatus*	70	0.4
Igabalo	Acanthuridae	*Acanthurus guttatus*	70	0.4
Sio	Pomacanthidae	*Pygoplites* spp.	70	0.4
Sikoronihau	Serranidae	*Epinephelus merra*	70	0.4
Pakataniponi	Acanthuridae	*Naso* spp.	70	0.4
Bubuma	Scaridae	*Scarus globiceps*	70	0.4
Manauri	Sphyraenidae	*Sphyraena novaehollandiae*	54	0.3
Iapo	Haemulidae	*Plectorhinchus flavomaculatus*	51	0.3
Mamula	Carangidae	*Carangoides* spp.	47	0.2
Naoniai	Serranidae	*Plectropomus* spp.	47	0.2
Pasau	Carangidae	*Caranx melampygus*	47	0.2
Maroho	Carangidae	*Elagatis bipinnulata*	47	0.2
Mumuku	Balistidae	*Balistapus undulatus*	47	0.2
Piru	Carangidae	*Caranx ignobilis*	35	0.2
Kubuku	Balistidae	*Pseudobalistes* spp.	35	0.2
Ededa	Sphyraenidae	*Sphyraena* spp.	35	0.2
Bubu	Balistidae	*Melichthys* spp.	23	0.1
Paqe	Centrarchidae	*Acantharchus pomotis*	23	0.1
Total:			**19,396**	**100.0**

2.2.1 Annual catch (kg) of fish groups per habitat – Marau (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & outer reef				
Merasau	Pomacentridae	*Amphiprion clarkii*	109	38.9
Suru	Haemulidae	*Plectorhinchus celebicus*	93	33.3
Rakui			78	27.8
Total:			**279**	**100.1**
Lagoon & outer reef				
Pakata	Acanthuridae	*Naso* spp.	239	10.1
Korusisi	Lutjanidae	*Lutjanus sebae*	239	10.1
Labiago	Lutjanidae	*Aphareus furca*	195	8.2
Huhuone	Scombridae	*Scomberomorus* spp.	146	6.2
Agoago	Haemulidae	*Plectorhinchus* spp.	140	5.9
Uku	Balistidae, Carangidae	*Caranx* spp., *Rhinecanthus verrucosus*	122	5.1
Mara	Scaridae	*Scarus* spp.	121	5.1
Araokeoke	Lutjanidae	*Lutjanus bohar*	108	4.6
Usiusi	Acanthuridae	*Naso* spp.	102	4.3
Huruhiu	Sphyraenidae	*Sphyraena* spp.	91	3.8
Alulu	Carangidae	*Caranx* spp.	87	3.7
Rada			87	3.7
Paa	Acanthuridae	*Acanthurus* spp.	85	3.6
Rauniponi	Haemulidae	*Plectorhinchus lineatus*, *Plectorhinchus vittatus*	85	3.6
Asu	Lethrinidae	*Gnathodentex aureolineatus*	70	2.9
Kama kalua	Labridae	*Halichoeres chloropterus*	70	2.9
Paumatana	Scaridae	*Scarus rubroviolaceus*	70	2.9
Naoniai	Serranidae	*Plectropomus* spp.	58	2.5
Manauri	Sphyraenidae	*Sphyraena novaehollandiae*	58	2.5
Makasi	Scombridae	*Sarda* spp.	52	2.2
Maua	Scaridae	*Scarus ghobban*	52	2.2
Reto	Scombridae	*Euthynnus* spp.	38	1.6
Tangiri	Scombridae	*Scomberomorus commerson*	35	1.5
Puri	Carangidae	*Selaroides leptolepis*	23	1.0
Total:			**2374**	**100.0**
Outer reef				
Urahu	Serranidae	*Epinephelus* spp.	952	7.8
Marawa	Scaridae	*Scarus rubroviolaceus*	946	7.8
Huruhiu	Sphyraenidae	*Sphyraena* spp.	945	7.8
Pakata	Acanthuridae	*Naso* spp.	673	5.5
Huhuone	Scombridae	*Scomberomorus* spp.	523	4.3
Korusisi	Lutjanidae	*Lutjanus sebae*	490	4.0
Marihu	Lutjanidae	*Lutjanus gibbus*	428	3.5
Suru	Haemulidae	*Plectorhinchus celebicus*	373	3.1
Korosa	Serranidae	*Cephalopholis* spp.	359	3.0
Paumatana	Scaridae	*Scarus rubroviolaceus*	302	2.5
Usiusi	Acanthuridae	*Naso* spp.	286	2.4
Rau	Sphyraenidae	*Sphyraena* spp.	265	2.2
Korakora	Mugilidae	*Valamugil* spp.	245	2.0

2.2.1 Annual catch (kg) of fish groups per habitat – Marau (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef (continued)				
Osanga	Lethrinidae	*Lethrinus* spp.	244	2.0
Atukere	Scombridae	*Gymnosarda unicolor*	229	1.9
Parauro	Sphyraenidae	*Sphyraena forsteri*	228	1.9
Suru vatora	Haemulidae	*Plectorhinchus* spp.	221	1.8
Agoago	Haemulidae	*Plectorhinchus* spp.	218	1.8
Reto	Scombridae	*Euthynnus* spp.	216	1.8
Pasahu	Carangidae	*Caranx* spp.	215	1.8
Tangiri	Scombridae	*Scomberomorus commerson*	214	1.8
Porapora	Labridae	*Cheilinus undulatus*	199	1.6
Bubu	Balistidae	*Melichthys* spp.	186	1.5
Mamula	Carangidae	*Carangoides* spp.	181	1.5
Ririhu			180	1.5
Puri	Carangidae	*Selaroides leptolepis*	172	1.4
Kimasi	Lutjanidae	*Lutjanus* spp.	168	1.4
Papaere	Lethrinidae	*Lethrinus* spp.	165	1.4
Arupara	Siganidae	*Siganus lineatus*	162	1.3
Kima asi	Lutjanidae	*Lutjanus* spp.	161	1.3
Igabalo	Acanthuridae	*Acanthurus guttatus*	146	1.2
Merasau	Pomacentridae	*Amphiprion clarkii*	144	1.2
Naoniai	Serranidae	*Plectropomus* spp.	121	1.0
Aniri	Scombridae	*Scomberomorus commerson*	119	1.0
Matasi	Mullidae	*Parupeneus* spp.	105	0.9
Watora	Lethrinidae	*Lethrinus olivaceus*	98	0.8
Apisihata	Holocentridae	*Myripristis adusta*	93	0.8
Pupu	Balistidae	*Abalistes stellaris*	87	0.7
Langolango	Lutjanidae	*Lutjanus* spp.	86	0.7
Rauniponi	Haemulidae	*Plectorhinchus lineatus, Plectorhinchus vittatus*	76	0.6
Kara	Carangidae	*Carangoides* spp.	74	0.6
Makoto	Balistidae	*Balistapus* spp.	72	0.6
Mihu	Lutjanidae	*Lutjanus* spp.	70	0.6
Mumu	Haemulidae	*Plectorhinchus obscurus*	70	0.6
Piru	Carangidae	*Caranx ignobilis*	70	0.6
Mara	Scaridae	*Scarus* spp.	70	0.6
Sori	Holocentridae	*Myripristis* spp.	70	0.6
Paere	Lethrinidae	*Lethrinus genivittatus*	70	0.6
Mala	Mullidae	*Parupeneus trifasciatus*	70	0.6
Akoru	Carangidae	*Elagatis bipinnulata*	51	0.4
Kama kalua	Labridae	*Halichoeres chloropterus*	49	0.4
Wahu	Scombridae	*Acanthocybium solandri*	47	0.4
Karikari	Mugilidae	*Mugil* spp.	47	0.4
Mawauri	Acanthuridae	*Naso unicornis*	35	0.3
Kima	Lutjanidae	*Lutjanus* spp.	35	0.3
Mu	Siganidae	*Siganus doliatus*	17	0.1
Total:			**12,141**	**100.0**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Marau

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Ura	*Panulirus* spp.	76.0
	Hikama	*Panulirus* spp.	24.0
Mangrove	Kape	*Scylla serrata*	88.4
	Ropi	*Terebralia palustris*	11.6
Other	Hulumu	*Tridacna* spp.	100.0
Reeftop & other	Meno	*Tridacna maxima*	61.3
	Hato	*Trochus niloticus*	8.7
	Mera	*Strombus* spp.	5.9
	Arimango	*Scylla serrata*	5.7
	Ura	*Panulirus* spp.	5.4
	Opora	*Scylla serrata*	3.8
	Tavai	*Tripneustes gratilla*	3.4
	Piawai	*Tridacna gigas*	2.7
	Pisiu	*Octopus* spp.	2.1
	Nara	*Lambis lambis*	1.0
	Deo	*Modiolus auriculatus*	0.1
	Meta	*Nerita* spp.	0.1
Reeftop & trochus & other	Hato	*Trochus niloticus*	68.9
	Arimango	*Scylla serrata*	16.1
	Meno	*Tridacna maxima*	11.5
	Nara	*Lambis lambis*	2.7
	Mera	*Strombus* spp.	0.9
Intertidal & reeftop	Mera	*Strombus* spp.	39.0
	Sipiu	*Octopus* spp.	28.6
	Nara	*Lambis lambis*	26.0
	Sise	*Nerita polita*	6.5
Intertidal & reeftop & other	Taura	*Tridacna maxima*	56.8
	Meno	*Tridacna maxima*	20.4
	Hutehute	*Sipunculus* spp.	18.2
	Meta	*Nerita* spp.	2.8
	Mera	*Strombus* spp.	1.8
Soft benthos & mangrove	Mahuri	*Holothuria* spp.	24.1
	Arimango	*Scylla serrata*	20.2
	Hutehute	*Sipunculus* spp.	15.2
	Tahuri	*Tridacna* spp.	9.0
	Mera	*Strombus* spp.	6.9
	Oreore	*Donax cuneatus*	5.9
	Keu		4.8
	Meno	*Tridacna maxima*	3.9
	Kape	*Scylla serrata*	3.4
	Roa	*Pinctada margaritifera*	2.4
	Tavai	*Tripneustes gratilla*	1.8
	U	*Telescopium telescopium*	1.4
	Nara	*Lambis lambis*	1.0
	Meta	*Nerita* spp.	0.1

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Marau (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & mangrove & reeftop & other	Opora	*Scylla serrata*	63.2
	Panamou	*Tectus* spp.	20.3
	Hutehute	*Sipunculus* spp.	8.5
	Arimango	*Scylla serrata*	6.3
	Nara	*Lambis lambis*	1.7
Soft benthos & reeftop & other	Meno	*Tridacna maxima*	42.3
	Panamou	*Tectus* spp.	34.6
	Mera	*Strombus* spp.	17.3
	Nara	*Lambis lambis*	3.8
	Deo	*Modiolus auriculatus*	1.9
Trochus	Hato	*Trochus niloticus*	100.0

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Marau

Vernacular name	Scientific name	Size class	% of total catch (weight)
Arimango	*Scylla serrata*	08–14 cm	14.8
		10–12 cm	59.3
		10–14 cm	13.6
		12–16 cm	12.3
Deo	*Modiolus auriculatus*	08–12 cm	87.0
		12–14 cm	13.0
Hato	*Trochus niloticus*	10–12 cm	79.3
		12–16 cm	20.7
Hikama	*Panulirus* spp.	18–22 cm	100.0
Hulumu	*Tridacna* spp.	14–18 cm	100.0
Hutehute	*Sipunculus* spp.	02–03 cm	25.8
		02–04 cm	74.2
Kape	*Scylla serrata*	14–18 cm	100.0
Keu		06–10 cm	100.0
Mahuri	*Holothuria* spp.	04–08 cm	100.0
Meno	*Tridacna maxima*	08–14 cm	3.9
		10–12 cm	3.9
		10–14 cm	23.9
		10–16 cm	6.6
		12–14 cm	29.5
		12–15 cm	13.1
		12–16 cm	15.8
		14–15 cm	3.3
Mera	*Strombus* spp.	02–06 cm	30.7
		04–06 cm	41.1
		06 cm	28.2
Meta	*Nerita* spp.	02–04 cm	82.8
		02–06 cm	17.2

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Marau (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Nara	*Lambis lambis*	05–07 cm	5.7
		06–08 cm	57.0
		08–10 cm	4.3
		08–12 cm	17.4
		08–14 cm	12.8
		10–12 cm	2.8
Opora	*Scylla serrata*	06–10 cm	88.9
		10–12 cm	11.1
Oreore	*Donax cuneatus*	04–08 cm	12.3
		04–10 cm	9.2
		06–08 cm	18.5
		06–09 cm	9.2
		06–10 cm	50.8
Panamou	*Tectus* spp.	04–06 cm	54.5
		06–08 cm	45.5
Piawai	*Tridacna gigas*	12–14 cm	100.0
Pisiu	*Octopus* spp.	12–14 cm	57.1
		12–16 cm	42.9
Roa	*Pinctada margaritifera*	16–18 cm	100.0
Ropi	*Terebralia palustris*	06–08 cm	100.0
Sipiu	*Octopus* spp.	12–14 cm	100.0
Sise	*Nerita polita*	04–08 cm	100.0
Tahuri	*Tridacna* spp.	16–18 cm	100.0
Taura	*Tridacna maxima*	02–06 cm	100.0
Tavai	*Tripneustes gratilla*	04–08 cm	54.3
		06–08 cm	45.7
U	*Telescopium telescopium*	02–06 cm	100.0
Ura	*Panulirus* spp.	14–18 cm	7.1
		18–22 cm	92.9

2.3 Rarumana socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat – Rarumana
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Mara	Scaridae	*Scarus* spp.	375	14.7
Osanga	Lethrinidae	*Lethrinus* spp.	337	13.2
Makoto	Balistidae	*Balistapus* spp.	268	10.4
Heheuku	Lutjanidae	*Lutjanus* spp.	233	9.1
Ramusi	Lethrinidae	*Lethrinus* spp.	229	9.0
Suru	Haemulidae	*Plectorhinchus celebicus*	215	8.4
Mihu	Lutjanidae	*Lutjanus* spp.	194	7.6
Pepata	Lethrinidae	*Lethrinus genivittatus*	139	5.4
Kanizi	Labridae	*Halichoeres* spp.	127	4.9
Tarasi	Acanthuridae	*Acanthurus* spp.	120	4.7
Malaki	Scaridae	*Scarus* spp.	109	4.3
Talia	Labridae	*Cheilinus* spp.	96	3.7
Ganusu	Mugilidae	*Mugil* spp.	65	2.5
Lipa	Mugilidae	*Mugil* spp.	33	1.3
Mumu	Haemulidae	*Plectorhinchus obscurus*	22	0.9
Total:			2560	100.0
Sheltered coastal reef & lagoon				
Mihu	Lutjanidae	*Lutjanus* spp.	1758	13.4
Osanga	Lethrinidae	*Lethrinus* spp.	1396	10.6
Ramusi	Lethrinidae	*Lethrinus* spp.	1121	8.5
Pazara	Serranidae	*Cephalopholis* spp.	694	5.3
Mara	Scaridae	*Scarus* spp.	667	5.1
Heheuku	Lutjanidae	*Lutjanus* spp.	639	4.9
Lipa	Mugilidae	*Mugil* spp.	608	4.6
Pepata	Lethrinidae	*Lethrinus genivittatus*	597	4.5
Kanizi	Labridae	*Halichoeres* spp.	546	4.2
Makoto	Balistidae	*Balistapus* spp.	492	3.7
Suru	Haemulidae	*Plectorhinchus celebicus*	467	3.5
Tarasi	Acanthuridae	*Acanthurus* spp.	408	3.1
Malaki	Scaridae	*Scarus* spp.	339	2.6
Ganusu	Mugilidae	*Mugil* spp.	302	2.3
Kidakale	Siganidae	*Siganus spinus*	284	2.2
Igana	Caesionidae	*Caesio* spp.	274	2.1
Malboro	Carangidae	*Selaroides leptolepis*	263	2.0
Kuva	Serranidae	*Cephalopholis argus*	262	2.0
Talia	Labridae	*Cheilinus* spp.	261	2.0
Pakao	Mullidae	*Mulloidichthys* spp.	248	1.9
Ulafu	Serranidae	*Cephalopholis* spp.	194	1.5
Mumu	Haemulidae	*Plectorhinchus obscurus*	186	1.4
Pipirikoho	Haemulidae	*Plectorhinchus* spp.	185	1.4
Cororo	Serranidae	*Cromileptes* spp.	128	1.0
Kulipatu	Serranidae	*Epinephelus polyphekadion*	105	0.8
Mamula	Carangidae	*Carangoides* spp.	100	0.8
Kuluma	Balistidae	*Rhinecanthus* spp.	87	0.7

2.3.1 Annual catch (kg) of fish groups per habitat – Rarumana (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon (continued)				
Hangafa	Labridae	*Cheilinus fasciatus*	81	0.6
Tatara	Lutjanidae	*Lutjanus kasmira*	81	0.6
Sina	Lutjanidae	*Lutjanus rivulatus*	80	0.6
Tangiri	Scombridae	*Scomberomorus commerson*	80	0.6
Mumuku	Balistidae	*Balistapus undulatus*	67	0.5
Maranga	Scaridae	*Scarus* spp.	57	0.4
Iganana zignra	Lutjanidae	*Lutjanus gibbus*	38	0.3
Ulele	Serranidae	*Variola* spp.	38	0.3
Ringo	Lutjanidae, Scombridae	*Euthynnus* spp., *Lutjanus bohar*	22	0.2
Total:			**13,156**	**100.0**
Lagoon				
Mihu	Lutjanidae	*Lutjanus* spp.	178	34.1
Osanga	Lethrinidae	*Lethrinus* spp.	172	32.9
Mara	Scaridae	*Scarus* spp.	172	32.9
Total:			**523**	**100.0**
Sheltered coastal reef & lagoon & outer reef				
Tarasi	Acanthuridae	*Acanthurus* spp.	91	42.2
Pakao	Mullidae	*Mulloidichthys* spp.	74	34.4
Suru	Haemulidae	*Plectorhinchus celebicus*	50	23.3
Total:			**215**	**99.9**
Lagoon & outer reef				
Mara	Scaridae	*Scarus* spp.	212	49.4
Ramusi	Lethrinidae	*Lethrinus* spp.	67	15.6
Talia	Labridae	*Cheilinus* spp.	50	11.7
Osanga	Lethrinidae	*Lethrinus* spp.	33	7.8
Cororo	Serranidae	*Cromileptes* spp.	33	7.8
Kanize	Labridae	*Halichoeres* spp.	33	7.8
Total:			**429**	**100.0**
Outer reef				
Pazara	Serranidae	*Cephalopholis* spp.	490	22.7
Pakao	Mullidae	*Mulloidichthys* spp.	480	22.3
Pepata	Lethrinidae	*Lethrinus genivittatus*	295	13.7
Hangafa	Labridae	*Cheilinus fasciatus*	197	9.1
Talia	Labridae	*Cheilinus* spp.	143	6.6
Tarasi	Acanthuridae	*Acanthurus* spp.	121	5.6
Kanizi	Labridae	*Halichoeres* spp.	107	5.0
Heheuku	Lutjanidae	*Lutjanus* spp.	99	4.6
Rora	Carangidae	*Alectis ciliaris*	91	4.2
Mihu	Lutjanidae	*Lutjanus* spp.	67	3.1
Makoto	Balistidae	*Balistapus* spp.	67	3.1
Total:			**2157**	**100.0**

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Rarumana

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Hikama	*Panulirus* spp.	100.0
Mangrove	Deo	*Modiolus auriculatus*	47.3
	Riki	*Anadara* spp.	27.1
	Roga	*Saccostrea* spp.	8.7
	Ropi	*Terebralia palustris*	5.9
	Ghuhum	*Tridacna maxima*	4.9
	Kape	*Scylla serrata*	4.1
	Oreore	*Donax cuneatus*	1.2
	Aau	*Anadara* spp.	0.8
Other	Hohobulu	*Hippopus hippopus*	42.5
	Pengpeng	*Tridacna crocea*	37.0
	Taura	*Tridacna maxima*	8.2
	Tahuri	*Tridacna* spp.	8.2
	Bikoho	*Trochus niloticus*	4.1
Reeftop	Pengpeng	*Tridacna crocea*	94.3
	Sise	*Nerita polita*	5.7
Reeftop & other	Hohobulu	*Hippopus hippopus*	26.3
	Peopeo	*Charonia tritonis*	20.1
	Pengpeng	*Tridacna crocea*	15.4
	Veruveru	*Tridacna* spp.	10.8
	Bikoho	*Trochus niloticus*	8.1
	Hulumu	*Tridacna* spp.	3.8
	Ununus	*Strombus* spp.	2.4
	Vulumu	*Tridacna* spp.	2.1
	Sipiu	*Octopus* spp.	2.1
	Ropi	*Terebralia palustris*	1.9
	Panamou	*Tectus* spp.	1.5
	Kapehe	*Scylla serrata*	1.4
	Hio	*Tridacna gigas*	0.9
	Poputo	*Turbo* spp.	0.7
	Ringasa	*Lambis lambis*	0.6
	Tavai	*Tripneustes gratilla*	0.5
	Tawaii	*Tripneustes* spp.	0.4
	Paupasua	*Thais* spp.	0.2
	Sise	*Nerita polita*	0.1
	Ropiatu	*Telescopium telescopium*	0.1
	Riki	*Anadara* spp.	0.1
	Huhute	*Donax cuneatus*	0.1
	Keke	*Anadara* spp.	0.1
	Rariri	*Turbo* spp.	0.1
	Kauia	*Periglypta reticulata*	0.0
	Nawa	*Lambis* spp.	0.0
	Ariri	*Turbo* spp.	0.0
	Ime		

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Rarumana (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Reeftop & mother-of-pearl & other	Pou	*Holothuria* spp.	42.0
	Hohobulu	*Hippopus hippopus*	27.6
	Hulumu	*Tridacna* spp.	9.2
	Bikoho	*Trochus niloticus*	7.9
	Tawaii	*Tripneustes* spp.	5.0
	Riki	*Anadara* spp.	3.3
	Lala	*Trochus niloticus*	3.2
	Sise	*Nerita polita*	1.5
	U	*Telescopium telescopium*	0.4
Sand & reeftop	Ununus	*Strombus* spp.	55.0
	Veruveru	*Tridacna* spp.	22.9
	Bikoho	*Trochus niloticus*	6.1
	Sise	*Nerita polita*	4.8
	Ringasa	*Lambis lambis*	4.6
	Pengpeng	*Tridacna crocea*	2.8
	Sipiu	*Octopus* spp.	1.7
	Poputo	*Turbo* spp.	0.7
	Nawa	*Lambis* spp.	0.5
	Keke	*Anadara* spp.	0.4
	Rariri	*Turbo* spp.	0.2
	Manuri	*Pitar prora*	0.2
	Ime		
Sand & reeftop & other	Veruveru	*Tridacna* spp.	36.2
	Peopeo	*Charonia tritonis*	18.5
	Ununus	*Strombus* spp.	16.3
	Pengpeng	*Tridacna crocea*	12.8
	Hulumu	*Tridacna* spp.	4.6
	Sisi	*Tridacna derasa*	4.1
	Ghuhum	*Tridacna maxima*	2.6
	Poputo	*Turbo* spp.	1.5
	Inunus	*Asaphis violascens*	1.5
	Sise	*Nerita polita*	0.6
	Ringasa	*Lambis lambis*	0.4
	Paupasua	*Thais* spp.	0.3
	Rariri	*Turbo* spp.	0.3
	Nawa	*Lambis* spp.	0.2
	Huhute	*Donax cuneatus*	0.1
Soft benthos & mangrove	Kape	*Scylla serrata*	43.3
	Riki	*Anadara* spp.	23.3
	Deo	*Modiolus auriculatus*	15.3
	Ropi	*Terebralia palustris*	5.4
	Kakautia	*Cardisoma* spp.	4.5
	Ununus	*Strombus* spp.	3.6
	Roga	*Saccostrea* spp.	1.2
	Keke	*Anadara* spp.	0.9
	Ringasa	*Lambis lambis*	0.9
	Hakakazoa	*Spondylus* spp.	0.6

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Rarumana (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & mangrove (continued)	Ropiatu	*Telescopium telescopium*	0.5
	Nawa	*Lambis* spp.	0.4
	Oreore	*Donax cuneatus*	0.3
Soft benthos & sand & reeftop	Hulumu	*Tridacna* spp.	54.0
	Arimango	*Scylla serrata*	30.2
	Panamou	*Tectus* spp.	11.1
	Ununus	*Strombus* spp.	3.9
	Sise	*Nerita polita*	0.8
Soft benthos & sand & reeftop & other	Ununus	*Strombus* spp.	28.2
	Pengpeng	*Tridacna crocea*	25.3
	Peo	*Charonia tritonis*	23.0
	Ghuhum	*Tridacna maxima*	11.5
	Gharumu	*Cardisoma* spp.	4.9
	Riki	*Anadara* spp.	3.0
	Roga	*Saccostrea* spp.	2.0
	Hohobulu	*Hippopus hippopus*	1.2
	Ringasa	*Lambis lambis*	0.3
	Rariri	*Turbo* spp.	0.3
	Nawa	*Lambis* spp.	0.2
Mother-of-pearl & other	Hohobulu	*Hippopus hippopus*	62.8
	Bikoho	*Trochus niloticus*	37.2

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Rarumana

Vernacular name	Scientific name	Size class	% of total catch (weight)
Aau	*Anadara* spp.	06 cm	100.0
Arimango	*Scylla serrata*	08–12 cm	100.0
Ariri	*Turbo* spp.	06–12 cm	100.0
Bikoho	*Trochus niloticus*	04–06 cm	55.1
		08–12 cm	5.5
		08–14 cm	20.2
		10–12 cm	3.2
		10–14 cm	9.2
		12–16 cm	6.9
Deo	*Modiolus auriculatus*	03–06 cm	25.3
		04–06 cm	65.7
		04–08 cm	1.3
		06–08 cm	7.7
Gharumu	*Cardisoma* spp.	08–10 cm	100.0
Ghuhum	*Tridacna maxima*	08–10 cm	10.6
		10–12 cm	21.3
		10–18 cm	68.1
Hakakazoa	*Spondylus* spp.	08–10 cm	100.0
Hikama	*Panulirus* spp.	18–22 cm	82.0
		18–24 cm	18.0
Hio	*Tridacna gigas*	10–12 cm	100.0

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Rarumana (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Hohobulu	*Hippopus hippopus*	10–12 cm	19.3
		10–14 cm	24.2
		12–14 cm	39.0
		12–16 cm	16.3
		12–20 cm	1.2
Huhute	*Donax cuneatus*	08–10 cm	52.9
		08–12 cm	47.1
Hulumu	*Tridacna* spp.	06–08 cm	39.3
		12–14 cm	29.2
		12–16 cm	31.5
Ime		01 cm	
Inunus	*Asaphis violascens*	04–06 cm	100.0
Kakautia	*Cardisoma* spp.	12–16 cm	68.5
		16–18 cm	31.5
Kape	*Scylla serrata*	12–16 cm	24.9
		12–18 cm	5.5
		13–18 cm	8.3
		14–18 cm	12.4
		14–20 cm	8.3
		16–20 cm	40.6
Kapehe	*Scylla serrata*	12–14 cm	100.0
Kauia	*Periglypta reticulata*	10–14 cm	100.0
Keke	*Anadara* spp.	06 cm	100.0
Lala	*Trochus niloticus*	08–12 cm	100.0
Manuri	*Pitar prora*	07–10 cm	100.0
Nawa	*Lambis* spp.	07–10 cm	12.1
		08–10 cm	50.0
		08–12 cm	37.9
Oreore	*Donax cuneatus*	06–08 cm	100.0
Panamou	*Tectus* spp.	08–10 cm	44.4
		08–12 cm	55.6
Paupasua	*Thais* spp.	06–08 cm	49.6
		07–08 cm	50.4
Pengpeng	*Tridacna crocea*	08–12 cm	7.1
		08–14 cm	11.3
		10–12 cm	7.1
		10–14 cm	18.3
		10–15 cm	3.7
		12–14 cm	31.9
		12–16 cm	12.3
		13–15 cm	7.1
		14–18 cm	1.3
Peo	*Charonia tritonis*	10–12 cm	100.0
Peopeo	*Charonia tritonis*	08–14 cm	14.7
		10–14 cm	8.7
		12–14 cm	38.6
		12–16 cm	37.9
Poputo	*Turbo* spp.	04–06 cm	100.0

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Rarumana (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Pou	*Holothuria* spp.	08–14 cm	100.0
Rariri	*Turbo* spp.	06–10 cm	32.3
		08–10 cm	67.7
Riki	*Anadara* spp.	03–06 cm	18.3
		04–06 cm	53.1
		05–06 cm	5.4
		06 cm	23.3
Ringasa	*Lambis lambis*	08–10 cm	1.2
		08–12 cm	16.1
		08–14 cm	27.4
		09–12 cm	6.5
		10–14 cm	37.0
		12–14 cm	7.6
		12–16 cm	4.3
Roga	*Saccostrea* spp.	06–10 cm	40.8
		08–10 cm	40.8
		14–18 cm	8.2
		16–22 cm	10.2
Ropi	*Terebralia palustris*	04–06 cm	100.0
Ropiatu	*Telescopium telescopium*	04–06 cm	60.0
		08–10 cm	40.0
Sipiu	*Octopus* spp.	12–14 cm	100.0
Sise	*Nerita polita*	03–05 cm	32.1
		03–06 cm	3.8
		04–06 cm	64.1
Sisi	*Tridacna derasa*	12–14 cm	100.0
Tahuri	*Tridacna* spp.	12–14 cm	100.0
Taura	*Tridacna maxima*	12–14 cm	100.0
Tavai	*Tripneustes gratilla*	10–14 cm	100.0
Tawaii	*Tripneustes* spp.	10–14 cm	74.5
		12–14 cm	25.5
U	*Telescopium telescopium*	18–22 cm	100.0
Ununus	*Strombus* spp.	03–05 cm	1.0
		03–06 cm	33.9
		04–06 cm	64.1
		06 cm	1.0
Veruveru	*Tridacna* spp.	10–12 cm	3.2
		10–14 cm	17.9
		12–14 cm	58.8
		12–16 cm	13.6
		14–18 cm	4.3
		16–20 cm	2.1
Vulumu	*Tridacna* spp.	10–12 cm	60.0
		12–14 cm	40.0

2.4 Chubikopi socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat – Chubikopi
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon				
Mara	Scaridae	*Scarus* spp.	1327	13.6
Mihu	Lutjanidae	*Lutjanus* spp.	1064	10.9
Agoago	Haemulidae	*Plectorhinchus* spp.	850	8.7
Panjara	Serranidae	*Epinephelus fuscoguttatus*	743	7.6
Marogo	Lutjanidae	*Lutjanus adetii*	660	6.7
Heheuku	Lutjanidae	*Lutjanus* spp.	649	6.6
Ramusi	Lethrinidae	*Lethrinus* spp.	304	3.1
Kubuku	Balistidae	*Pseudobalistes* spp.	244	2.5
Chori	Holocentridae	*Myripristis vittata*	239	2.4
Dudu	Siganidae	*Siganus punctatus*	211	2.2
Keleo	Serranidae	*Aethaloperca rogaa*	207	2.1
Moturu	Scaridae	*Scarus* spp.	176	1.8
Pakata	Acanthuridae	*Naso* spp.	163	1.7
Karakara	Carangidae	*Carangoides coeruleopinnatus*	155	1.6
Dami popolo	Lethrinidae	*Lethrinus miniatus*, *Lethrinus* spp.	155	1.6
Vali	Dasyatidae	*Dasyatis* spp.	147	1.5
Uvoro	Lutjanidae	*Lutjanus* spp.	132	1.3
Ringo	Lutjanidae, Scombridae	*Euthynnus* spp., *Lutjanus bohar*	128	1.3
Marabatubatu	Carangidae	*Caranx ignobilis*	118	1.2
Belele	Lutjanidae	*Lutjanus* spp.	118	1.2
Koasa	Lutjanidae	*Lutjanus russellii*	111	1.1
Ihana orava	Lutjanidae	*Lutjanus sebae*	110	1.1
Tatewa	Lutjanidae	*Lutjanus* spp.	104	1.1
Tatavarao	Acanthuridae	*Naso lituratus*	101	1.0
Makoto	Balistidae	*Balistapus* spp.	96	1.0
Chamuhu	Belonidae	*Tylosurus* spp.	89	0.9
Pehu	Haemulidae	*Plectorhinchus gibbosus*	88	0.9
Poto	Diodontidae	*Diodon holocanthus*	73	0.7
Habili	Labridae	*Cheilinus* spp.	67	0.7
Malaki	Scaridae	*Scarus* spp.	67	0.7
Pangu	Acanthuridae	*Naso lituratus*	67	0.7
Porapora	Labridae	*Cheilinus undulatus*	67	0.7
Payara	Serranidae	*Cephalopholis miniata*	67	0.7
Papako	Carangidae	*Selar* spp.	67	0.7
Chikochiko mujiki	Labridae	*Cheilinus undulatus*	67	0.7
Ganusu	Mugilidae	*Mugil* spp.	67	0.7
Vudere	Lutjanidae	*Lutjanus fulvus*	66	0.7
Chocho	Hemiramphidae	*Zenarchopterus dispar*	59	0.6
Kitakita	Labridae	*Cheilinus* spp.	50	0.5
Haubele	Labridae	*Cirrhilabrus* spp.	50	0.5
Papaere	Lethrinidae	*Lethrinus* spp.	50	0.5
Davoro	Serranidae	*Cephalopholis* spp.	45	0.5
Maranga	Scaridae	*Scarus* spp.	45	0.5

2.4.1 Annual catch (kg) of fish groups per habitat – Chubikopi (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon (continued)				
Dongpusi	Nemipteridae	*Pentapodus* spp.	45	0.5
Moa	Carangidae	*Caranx* spp.	44	0.4
Buma	Carangidae	*Selar crumenophthalmus*	44	0.4
Lobaloba	Holocentridae	*Sargocentron spiniferum*	34	0.3
Paqe	Centrarchidae	*Acantharchus pomotis*	34	0.3
Bubuma	Scaridae	*Scarus globiceps*	22	0.2
Kara	Carangidae	*Carangoides* spp.	22	0.2
Igamea	Haemulidae	*Plectorhinchus gibbosus*	22	0.2
Kavala	Carangidae	*Scomberoides tala*	22	0.2
Katukatu			22	0.2
Ghalusu	Carangidae	*Selar boops*	14	0.1
Total:			**9790**	**100.0**
Lagoon				
Mihu	Lutjanidae	*Lutjanus* spp.	833	26.7
Sina	Lutjanidae	*Lutjanus rivulatus*	438	14.0
Marogo	Lutjanidae	*Lutjanus adetii*	290	9.3
Ringo	Lutjanidae, Scombridae	*Euthynnus* spp., *Lutjanus bohar*	244	7.8
Pazara	Serranidae	*Cephalopholis* spp.	243	7.8
Moturu	Scaridae	*Scarus* spp.	128	4.1
Marabatubatu	Carangidae	*Caranx ignobilis*	96	3.1
Susuri	Pleuronectidae	*Nematops microstoma*	96	3.1
Moa	Carangidae	*Caranx* spp.	84	2.7
Mara	Scaridae	*Scarus* spp.	67	2.1
Makoto	Balistidae	*Balistapus* spp.	67	2.1
Davivula	Lethrinidae	*Lethrinus* spp., *Monotaxis grandoculis*	67	2.1
Haubele	Labridae	*Cirrhilabrus* spp.	67	2.1
Suu	Serranidae	*Cephalopholis* spp.	67	2.1
Kiso	Carcharhinidae	*Carcharhinus* spp.	48	1.5
Soghasoghara	Lethrinidae	*Lethrinus olivaceus*	45	1.4
Koere	Acanthuridae	*Acanthurus lineatus*	45	1.4
Mangara	Lethrinidae	*Lethrinus miniatus*	45	1.4
Medomedo	Siganidae	*Siganus spinus*	45	1.4
Karapata	Lethrinidae	*Lethrinus* spp.	45	1.4
Ghuhe	Mullidae	*Parupeneus* spp.	34	1.1
Odingi	Mullidae	*Parupeneus* spp.	22	0.7
Davoro	Serranidae	*Cephalopholis* spp.	11	0.4
Total:			**3126**	**100.0**
Lagoon & outer reef				
Mara	Scaridae	*Scarus* spp.	814	18.6
Panjara	Serranidae	*Epinephelus fuscoguttatus*	577	13.2
Makoto	Balistidae	*Balistapus* spp.	328	7.5
Mihu	Lutjanidae	*Lutjanus* spp.	289	6.6
Kitakita	Labridae	*Cheilinus* spp.	288	6.6
Dudu	Siganidae	*Siganus punctatus*	237	5.4
Marogo	Lutjanidae	*Lutjanus adetii*	192	4.4

2.4.1 Annual catch (kg) of fish groups per habitat – Chubikopi (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon & outer reef (continued)				
Bubuma	Scaridae	*Scarus globiceps*	163	3.7
Kubuku	Balistidae	*Pseudobalistes* spp.	152	3.5
Agoago	Haemulidae	*Plectorhinchus* spp.	144	3.3
Jipojipolo	Labridae	*Anampses* spp.	140	3.2
Lipa	Mugilidae	*Mugil* spp.	132	3.0
Vanua	Scaridae	*Bolbometopon* spp.	110	2.5
Reka	Scombridae	*Euthynnus affinis*	105	2.4
Juapanato	Carangidae	*Elagatis* spp.	102	2.3
Davoro	Serranidae	*Cephalopholis* spp.	96	2.2
Piho	Lethrinidae	*Lethrinus nebulosus*	96	2.2
Chikochiko mujiki	Labridae	*Cheilinus undulatus*	67	1.5
Soghasoghara	Lethrinidae	*Lethrinus olivaceus*	67	1.5
Malaki	Scaridae	*Scarus* spp.	59	1.3
Moa	Carangidae	*Caranx* spp.	45	1.0
Dolatoto	Nemipteridae	*Scolopsis* spp.	45	1.0
Kare	Scaridae	*Bolbometopon* spp.	45	1.0
Tatalingi	Scombridae	*Thunnus albacares*	38	0.9
Medomedo	Siganidae	*Siganus spinus*	34	0.8
Ganusu	Mugilidae	*Mugil* spp.	14	0.3
Total:			**4376**	**100.0**
Outer reef				
Panjara	Serranidae	*Epinephelus fuscoguttatus*	317	9.1
Davivula	Lethrinidae	*Lethrinus* spp., *Monotaxis grandoculis*	298	8.6
Reka	Scombridae	*Euthynnus affinis*	266	7.7
Juapanato	Carangidae	*Elagatis* spp.	199	5.7
Ringo	Lutjanidae, Scombridae	*Euthynnus* spp., *Lutjanus bohar*	178	5.1
Ghohi	Sphyraenidae	*Sphyraena* spp.	177	5.1
Koasa	Lutjanidae	*Lutjanus russellii*	163	4.7
Davoro	Serranidae	*Cephalopholis* spp.	163	4.7
Tangiri	Scombridae	*Scomberomorus commerson*	153	4.4
Mamula	Carangidae	*Carangoides* spp.	148	4.3
Heheuku	Lutjanidae	*Lutjanus* spp.	134	3.9
Mihu	Lutjanidae	*Lutjanus* spp.	131	3.8
Marabatubatu	Carangidae	*Caranx ignobilis*	118	3.4
Pipo	Sphyraenidae	*Sphyraena* spp.	96	2.8
Vurusige	Lutjanidae	*Lutjanus semicinctus*	89	2.6
Kubuku	Balistidae	*Pseudobalistes* spp.	81	2.3
Makasi	Scombridae	*Sarda* spp.	81	2.3
Mara	Scaridae	*Scarus* spp.	79	2.3
Wahu	Scombridae	*Acanthocybium solandri*	74	2.1
Marogo	Lutjanidae	*Lutjanus adetii*	67	1.9
Makoto	Balistidae	*Balistapus* spp.	67	1.9
Tarasi	Acanthuridae	*Acanthurus* spp.	67	1.9
Ramusi	Lethrinidae	*Lethrinus* spp.	59	1.7
Agoago	Haemulidae	*Plectorhinchus* spp.	51	1.5

2.4.1 Annual catch (kg) of fish groups per habitat – Chubikopi (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef (continued)				
Pazara	Serranidae	*Cephalopholis* spp.	51	1.5
Bonito	Scombridae	*Sarda* spp.	51	1.5
Marihu	Lutjanidae	*Lutjanus gibbus*	37	1.1
Topa	Scaridae	*Bolbometopon muricatum*	25	0.7
Atu	Scombridae	*Thunnus orientalis*	22	0.6
Dudu	Siganidae	*Siganus punctatus*	15	0.4
Pehu	Haemulidae	*Plectorhinchus gibbosus*	15	0.4
Total:			**3472**	**100.0**
Outer reef & passage				
Panjara	Serranidae	*Epinephelus fuscoguttatus*	223	15.3
Mamula	Carangidae	*Carangoides* spp.	192	13.2
Makasi	Scombridae	*Sarda* spp.	172	11.8
Mara	Scaridae	*Scarus* spp.	163	11.2
Tangiri	Scombridae	*Scomberomorus commerson*	148	10.1
Marogo	Lutjanidae	*Lutjanus adetii*	118	8.1
Pazara	Serranidae	*Cephalopholis* spp.	118	8.1
Agoago	Haemulidae	*Plectorhinchus* spp.	89	6.1
Reka	Scombridae	*Euthynnus affinis*	74	5.1
Maranga	Scaridae	*Scarus* spp.	67	4.6
Topa	Scaridae	*Bolbometopon muricatum*	50	3.5
Odingi	Mullidae	*Parupeneus* spp.	45	3.1
Total:			**1458**	**100.0**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Chubikopi

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster & other	Tupe	*Birgus latro*	80.7
	Hikama	*Panulirus* spp.	9.3
	Ununus	*Strombus* spp.	5.8
	Riki	*Anadara* spp.	4.2
Mangrove	Kakarita	*Scylla serrata*	43.4
	Arimango	*Scylla serrata*	14.1
	Kasuisui	*Cardisoma* spp.	11.5
	Jinen	*Hyotissa* spp.	10.1
	Ropi	*Terebralia palustris*	8.4
	Deo	*Modiolus auriculatus*	7.9
	Riki	*Anadara* spp.	3.2
	Kakautia	*Cardisoma* spp.	1.4
Mangrove & other	Ropi	*Terebralia palustris*	76.1
	Deo	*Modiolus auriculatus*	23.9
Other	Hohobulu	*Hippopus hippopus*	28.1
	Mapa	*Parribacus antarcticus*	20.3
	Tupe	*Birgus latro*	18.0
	Piawai	*Tridacna gigas*	7.5
	Apuri	*Hippopus hippopus*	6.2

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Chubikopi (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Other (continued)	Hulumu	*Tridacna* spp.	5.8
	Sisi	*Tridacna derasa*	5.4
	Ununus	*Strombus* spp.	4.9
	Kasuisui	*Cardisoma* spp.	3.3
	Ghuhum	*Tridacna maxima*	0.5
Reeftop	Hulumu	*Tridacna* spp.	49.1
	Hikama	*Panulirus* spp.	25.0
	Apuri	*Hippopus hippopus*	14.3
	Ununus	*Strombus* spp.	8.5
	Sise	*Nerita polita*	3.1
Reeftop & other	Sisi	*Tridacna derasa*	49.2
	Hulumu	*Tridacna* spp.	17.9
	Hohobulu	*Hippopus hippopus*	13.6
	Hikama	*Panulirus* spp.	6.7
	Ose	*Tridacna gigas, T.* spp.	5.3
	Ununus	*Strombus* spp.	3.0
	Bikoho	*Trochus niloticus*	1.7
	Sise	*Nerita polita*	0.9
	Veruveru	*Tridacna* spp.	0.9
	Sipiu	*Octopus* spp.	0.8
Intertidal & reeftop	Hulumu	*Tridacna* spp.	36.9
	Ununus	*Strombus* spp.	21.0
	Karogo	*Trochus niloticus*	15.5
	Ropi	*Terebralia palustris*	12.5
	Sise	*Nerita polita*	7.7
	Livogivisi	*Acanthopleura* spp.	5.5
	Riki	*Anadara* spp.	0.9
Intertidal & reeftop & other	Mapa	*Parribacus antarcticus*	68.1
	Ununus	*Strombus* spp.	10.6
	Hohobulu	*Hippopus hippopus*	10.4
	Chavi	*Tridacna maxima*	10.4
	Sise	*Nerita polita*	0.5
Soft benthos & mangrove	Kakarita	*Scylla serrata*	25.2
	Kakautia	*Cardisoma* spp.	15.2
	Arimango	*Scylla serrata*	11.8
	Roga	*Saccostrea* spp.	11.8
	Ropi	*Terebralia palustris*	11.6
	Deo	*Modiolus auriculatus*	8.8
	Ununus	*Strombus* spp.	7.1
	Ronga	*Lambis scorpius*	4.8
	Riki	*Anadara* spp.	3.7

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Chubikopi

Vernacular name	Scientific name	Size class	% of total catch (weight)
Apuri	*Hippopus hippopus*	12–16 cm	100.0
Arimango	*Scylla serrata*	14–18 cm	100.0
Bikoho	*Trochus niloticus*	10–12 cm	100.0
Chavi	*Tridacna maxima*	10–16 cm	100.0
Deo	*Modiolus auriculatus*	03–04 cm	16.8
		03–06 cm	5.3
		04–06 cm	49.6
		06–08 cm	2.7
		06–10 cm	24.8
		08–10 cm	0.9
Ghuhum	*Tridacna maxima*	18–22 cm	100.0
Hikama	*Panulirus* spp.	12–16 cm	95.8
		14–18 cm	4.2
Hohobulu	*Hippopus hippopus*	10–12 cm	32.4
		10–14 cm	12.7
		10–16 cm	29.2
		12–16 cm	7.9
		14–16 cm	11.9
		14–18 cm	5.9
Hulumu	*Tridacna* spp.	06–08 cm	6.7
		08–10 cm	13.5
		08–12 cm	5.0
		10–12 cm	13.5
		10–14 cm	14.7
		10–16 cm	21.5
		12–14 cm	6.0
		12–16 cm	1.5
		14–16 cm	13.5
		14–18 cm	4.0
Jinen	*Hyotissa* spp.	04–06 cm	100.0
Kakarita	*Scylla serrata*	12–14 cm	32.1
		12–16 cm	16.6
		12–18 cm	51.3
Kakautia	*Cardisoma* spp.	12–16 cm	4.0
		14–18 cm	96.0
Karogo	*Trochus niloticus*	08–12 cm	100.0
Kasuisui	*Cardisoma* spp.	12–16 cm	100.0
Livogivisi	*Acanthopleura* spp.	02–04 cm	29.5
		06–08 cm	70.5
Mapa	*Parribacus antarcticus*	06–08 cm	100.0
Ose	*Tridacna gigas*, *Tridacna* spp.	10–16 cm	89.7
		18–22 cm	10.3
Piawai	*Tridacna gigas*	14–18 cm	100.0
Riki	*Anadara* spp.	04–05 cm	10.6
		04–06 cm	20.3
		06 cm	69.1
Roga	*Saccostrea* spp.	04–06 cm	50.0
		10–12 cm	50.0

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Chubikopi (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Ronga	*Lambis scorpius*	06–10 cm	100.0
Ropi	*Terebralia palustris*	03–04 cm	50.2
		04–06 cm	26.5
		06–08 cm	16.2
		06–10 cm	5.4
		10 cm	1.7
Sipiu	*Octopus* spp.	10–12 cm	100.0
Sise	*Nerita polita*	03–04 cm	19.7
		04–06 cm	69.7
		04–08 cm	10.6
Sisi	*Tridacna derasa*	12–14 cm	88.1
		12–16 cm	11.9
Tupe	*Birgus latro*	10–12 cm	28.6
		16–18 cm	71.4
Ununus	*Strombus* spp.	04–06 cm	80.6
		06 cm	19.4
Veruveru	*Tridacna* spp.	18–22 cm	100.0
Apuri	*Hippopus hippopus*	12–16 cm	100.0
Arimango	*Scylla serrata*	14–18 cm	100.0
Bikoho	*Trochus niloticus*	10–12 cm	100.0
Chavi	*Tridacna maxima*	10–16 cm	100.0
Deo	*Modiolus auriculatus*	03–04 cm	16.8
		03–06 cm	5.3
		04–06 cm	49.6
		06–08 cm	2.7
		06–10 cm	24.8
		08–10 cm	0.9
Ghuhum	*Tridacna maxima*	18–22 cm	100.0
Hikama	*Panulirus* spp.	12–16 cm	95.8
		14–18 cm	4.2
Hohobulu	*Hippopus hippopus*	10–12 cm	32.4
		10–14 cm	12.7
		10–16 cm	29.2
		12–16 cm	7.9
		14–16 cm	11.9
		14–18 cm	5.9
Hulumu	*Tridacna* spp.	06–08 cm	6.7
		08–10 cm	13.5
		08–12 cm	5.0
		10–12 cm	13.5
		10–14 cm	14.7
		10–16 cm	21.5
		12–14 cm	6.0
		12–16 cm	1.5
		14–16 cm	13.5
		14–18 cm	4.0
Jinen	*Hyotissa* spp.	04–06 cm	100.0

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Chubikopi (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Kakarita	*Scylla serrata*	12–14 cm	32.1
		12–16 cm	16.6
		12–18 cm	51.3
Kakautia	*Cardisoma* spp.	12–16 cm	4.0
		14–18 cm	96.0
Karogo	*Trochus niloticus*	08–12 cm	100.0
Kasuisui	*Cardisoma* spp.	12–16 cm	100.0
Livogivisi	*Acanthopleura* spp.	02–04 cm	29.5
		06–08 cm	70.5
Mapa	*Parribacus antarcticus*	06–08 cm	100.0
Ose	*Tridacna gigas*, *Tridacna* spp.	10–16 cm	89.7
		18–22 cm	10.3
Piawai	*Tridacna gigas*	14–18 cm	100.0
Riki	*Anadara* spp.	04–05 cm	10.6
		04–06 cm	20.3
		06 cm	69.1
Roga	*Saccostrea* spp.	04–06 cm	50.0
		10–12 cm	50.0
Ronga	*Lambis scorpius*	06–10 cm	100.0
Ropi	*Terebralia palustris*	03–04 cm	50.2
		04–06 cm	26.5
		06–08 cm	16.2
		06–10 cm	5.4
		10 cm	1.7
Sipiu	*Octopus* spp.	10–12 cm	100.0
Sise	*Nerita polita*	03–04 cm	19.7
		04–06 cm	69.7
		04–08 cm	10.6
Sisi	*Tridacna derasa*	12–14 cm	88.1
		12–16 cm	11.9
Tupe	*Birgus latro*	10–12 cm	28.6
		16–18 cm	71.4
Ununus	*Strombus* spp.	04–06 cm	80.6
		06 cm	19.4
Veruveru	*Tridacna* spp.	18–22 cm	100.0

APPENDIX 3: FINFISH SURVEY DATA

3.1 Nggela finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Nggela

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	8°58'03.6012" S	160°02'20.4" E
TRA02	Outer reef	8°56'54.1788" S	160°05'19.2012" E
TRA03	Outer reef	8°56'44.52" S	160°04'39.9612" E
TRA04	Outer reef	8°57'29.88" S	160°03'42.7212" E
TRA05	Outer reef	8°58'10.1388" S	160°04'15.3588" E
TRA06	Outer reef	8°59'37.9212" S	160°03'49.3812" E
TRA07	Outer reef	9°00'15.48" S	160°04'47.9388" E
TRA08	Outer reef	9°00'50.5188" S	160°04'37.0812" E
TRA09	Outer reef	9°01'58.8" S	160°04'04.44" E
TRA10	Outer reef	9°01'25.2588" S	160°03'36.6012" E
TRA11	Outer reef	8°59'48.0588" S	160°05'19.4388" E
TRA12	Outer reef	8°59'50.3412" S	160°05'48.48" E
TRA13	Outer reef	9°00'05.4" S	160°06'41.04" E
TRA14	Outer reef	9°00'28.26" S	160°05'57.7212" E
TRA15	Outer reef	8°57'29.34" S	160°06'30.3588" E
TRA16	Outer reef	8°58'50.8188" S	160°06'50.1012" E
TRA17	Outer reef	8°58'07.3812" S	160°06'47.0988" E
TRA18	Outer reef	8°56'47.4612" S	160°04'12.4788" E
TRA19	Outer reef	8°57'57.1788" S	160°03'20.0988" E
TRA20	Outer reef	8°58'45.3612" S	160°01'30.6012" E
TRA21	Outer reef	8°57'25.8588" S	160°02'03.1812" E
TRA22	Outer reef	8°57'44.7012" S	160°02'50.46" E
TRA23	Outer reef	8°57'10.0188" S	160°03'54.2988" E
TRA24	Outer reef	8°57'01.8612" S	160°03'27.36" E

3.1.2 Weighted average density and biomass of all finfish species recorded in Nggela (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	0.02167	20.771
Acanthuridae	*Acanthurus guttatus*	0.00158	0.354
Acanthuridae	*Acanthurus lineatus*	0.03556	12.860
Acanthuridae	*Acanthurus mata*	0.00100	0.810
Acanthuridae	*Acanthurus nigricans*	0.00008	0.006
Acanthuridae	*Acanthurus nigricauda*	0.00392	3.483
Acanthuridae	*Acanthurus olivaceus*	0.00033	0.110
Acanthuridae	*Acanthurus pyroferus*	0.02625	4.341
Acanthuridae	*Acanthurus thompsoni*	0.02956	1.320
Acanthuridae	*Acanthurus triostegus*	0.01717	1.255
Acanthuridae	*Acanthurus xanthopterus*	0.00108	0.952
Acanthuridae	*Ctenochaetus striatus*	0.12650	11.032
Acanthuridae	*Ctenochaetus tominiensis*	0.00117	0.059
Acanthuridae	*Naso annulatus*	0.00183	1.358
Acanthuridae	*Naso brevirostris*	0.00208	1.442

3.1.2 Weighted average density and biomass of all finfish species recorded in Nggela (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso hexacanthus*	0.00200	1.478
Acanthuridae	*Naso lituratus*	0.00683	3.618
Acanthuridae	*Naso thynnoides*	0.00075	0.514
Acanthuridae	*Naso unicornis*	0.00075	0.749
Acanthuridae	*Zebrasoma scopas*	0.01958	0.702
Acanthuridae	*Zebrasoma veliferum*	0.00050	0.052
Balistidae	*Balistapus undulatus*	0.01875	4.062
Balistidae	*Balistoides conspicillum*	0.00033	0.240
Balistidae	*Balistoides viridescens*	0.00017	0.220
Balistidae	*Melichthys niger*	0.00138	0.608
Balistidae	*Melichthys vidua*	0.00483	0.694
Balistidae	*Odonus niger*	0.00494	0.235
Balistidae	*Rhinecanthus verrucosus*	0.00017	0.006
Balistidae	*Sufflamen bursa*	0.00275	0.487
Balistidae	*Sufflamen chrysopterum*	0.00417	0.487
Belonidae	*Strongylura leiura*	0.00008	0.007
Caesionidae	*Caesio caerulaurea*	0.03590	18.621
Caesionidae	*Caesio cuning*	0.01117	3.561
Caesionidae	*Caesio teres*	0.02875	15.378
Caesionidae	*Pterocaesio pisang*	0.00056	0.040
Caesionidae	*Pterocaesio tile*	0.13095	12.883
Carangidae	*Carangoides ferdau*	0.00033	0.251
Carangidae	*Carangoides orthogrammus*	0.00008	0.010
Carangidae	*Caranx ignobilis*	0.00008	0.526
Carangidae	*Caranx melampygus*	0.00208	1.747
Carangidae	*Caranx papuensis*	0.00025	0.090
Carangidae	*Caranx sexfasciatus*	0.00033	0.305
Carangidae	*Caranx* spp.	0.00017	0.202
Carangidae	*Elagatis bipinnulata*	0.00117	0.867
Carangidae	*Scomberoides* spp.	0.00008	0.063
Carcharhinidae	*Carcharhinus amblyrhynchos*	0.00008	1.123
Carcharhinidae	*Carcharhinus melanopterus*	0.00075	14.577
Carcharhinidae	*Triaenodon obesus*	0.00017	2.330
Chaetodontidae	*Chaetodon auriga*	0.00050	0.025
Chaetodontidae	*Chaetodon baronessa*	0.00658	0.172
Chaetodontidae	*Chaetodon bennetti*	0.00017	0.013
Chaetodontidae	*Chaetodon citrinellus*	0.00442	0.081
Chaetodontidae	*Chaetodon ephippium*	0.00033	0.022
Chaetodontidae	*Chaetodon kleinii*	0.01417	0.330
Chaetodontidae	*Chaetodon lineolatus*	0.00033	0.008
Chaetodontidae	*Chaetodon lunula*	0.00142	0.043
Chaetodontidae	*Chaetodon lunulatus*	0.00933	0.288
Chaetodontidae	*Chaetodon melannotus*	0.00075	0.042
Chaetodontidae	*Chaetodon meyeri*	0.00025	0.021
Chaetodontidae	*Chaetodon octofasciatus*	0.00017	0.005
Chaetodontidae	*Chaetodon ornatissimus*	0.00017	0.006
Chaetodontidae	*Chaetodon pelewensis*	0.00017	0.007

3.1.2 Weighted average density and biomass of all finfish species recorded in Nggela (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon rafflesii*	0.00383	0.146
Chaetodontidae	*Chaetodon semeion*	0.00017	0.008
Chaetodontidae	*Chaetodon* spp.	0.00050	0.022
Chaetodontidae	*Chaetodon speculum*	0.00025	0.013
Chaetodontidae	*Chaetodon trifascialis*	0.00075	0.024
Chaetodontidae	*Chaetodon ulietensis*	0.00025	0.008
Chaetodontidae	*Chaetodon unimaculatus*	0.00092	0.054
Chaetodontidae	*Chaetodon vagabundus*	0.00492	0.171
Chaetodontidae	*Coradion altivelis*	0.00050	0.021
Chaetodontidae	*Forcipiger longirostris*	0.00175	0.106
Chaetodontidae	*Hemitaurichthys polylepis*	0.00383	0.205
Chaetodontidae	*Heniochus acuminatus*	0.00133	0.096
Chaetodontidae	*Heniochus chrysostomus*	0.00075	0.069
Chaetodontidae	*Heniochus singularius*	0.00033	0.032
Chaetodontidae	*Heniochus varius*	0.00333	0.270
Ephippidae	*Platax* spp.	0.00025	0.524
Haemulidae	*Plectorhinchus gibbosus*	0.00008	0.045
Haemulidae	*Plectorhinchus orientalis*	0.00150	0.895
Holocentridae	*Myripristis adusta*	0.00392	0.465
Holocentridae	*Myripristis berndti*	0.02636	4.041
Holocentridae	*Myripristis violacea*	0.00042	0.101
Holocentridae	*Neoniphon sammara*	0.00875	0.574
Holocentridae	*Sargocentron caudimaculatum*	0.00317	0.353
Holocentridae	*Sargocentron diadema*	0.00067	0.068
Holocentridae	*Sargocentron spiniferum*	0.00008	0.052
Kyphosidae	*Kyphosus vaigiensis*	0.00017	0.124
Labridae	*Cheilinus chlorourus*	0.00242	0.337
Labridae	*Cheilinus fasciatus*	0.00250	0.815
Labridae	*Cheilinus trilobatus*	0.00083	0.291
Labridae	*Cheilinus undulatus*	0.00058	0.774
Labridae	*Choerodon anchorago*	0.00283	0.677
Labridae	*Choerodon jordani*	0.00008	0.009
Labridae	*Hemigymnus fasciatus*	0.00200	0.194
Labridae	*Hemigymnus melapterus*	0.00725	1.265
Lethrinidae	*Gnathodentex aureolineatus*	0.00767	1.846
Lethrinidae	*Lethrinus amboinensis*	0.00058	0.405
Lethrinidae	*Lethrinus atkinsoni*	0.00017	0.201
Lethrinidae	*Lethrinus erythracanthus*	0.00042	0.330
Lethrinidae	*Lethrinus genivittatus*	0.00008	0.023
Lethrinidae	*Lethrinus harak*	0.00325	1.237
Lethrinidae	*Lethrinus olivaceus*	0.00042	0.341
Lethrinidae	*Lethrinus rubrioperculatus*	0.00008	0.042
Lethrinidae	*Lethrinus variegatus*	0.00008	0.013
Lethrinidae	*Lethrinus xanthochilus*	0.00025	0.154
Lethrinidae	*Monotaxis grandoculis*	0.02121	15.752
Lutjanidae	*Aphareus furca*	0.00075	0.501
Lutjanidae	*Aprion virescens*	0.00042	0.500

3.1.2 Weighted average density and biomass of all finfish species recorded in Nggela (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus biguttatus*	0.00008	0.007
Lutjanidae	*Lutjanus bohar*	0.00422	3.326
Lutjanidae	*Lutjanus fulviflamma*	0.01350	3.420
Lutjanidae	*Lutjanus fulvus*	0.00342	1.048
Lutjanidae	*Lutjanus gibbus*	0.02350	12.682
Lutjanidae	*Lutjanus monostigma*	0.00133	0.999
Lutjanidae	*Lutjanus semicinctus*	0.00300	1.230
Lutjanidae	*Macolor macularis*	0.00629	3.736
Lutjanidae	*Macolor niger*	0.00250	1.012
Mullidae	*Mulloidichthys flavolineatus*	0.00017	0.009
Mullidae	*Mulloidichthys vanicolensis*	0.01611	8.799
Mullidae	*Parupeneus barberinus*	0.00225	0.474
Mullidae	*Parupeneus cyclostomus*	0.00083	0.119
Mullidae	*Parupeneus multifasciatus*	0.00908	1.099
Nemipteridae	*Scolopsis affinis*	0.00033	0.077
Nemipteridae	*Scolopsis bilineata*	0.02749	3.550
Nemipteridae	*Scolopsis margaritifera*	0.00292	1.116
Nemipteridae	*Scolopsis temporalis*	0.00208	0.433
Nemipteridae	*Scolopsis trilineata*	0.00500	1.129
Pomacanthidae	*Apolemichthys trimaculatus*	0.00017	0.008
Pomacanthidae	*Centropyge bicolor*	0.00367	0.078
Pomacanthidae	*Centropyge loricula*	0.00017	0.004
Pomacanthidae	*Centropyge vrolikii*	0.00933	0.152
Pomacanthidae	*Pomacanthus imperator*	0.00017	0.088
Pomacanthidae	*Pomacanthus navarchus*	0.00033	0.145
Pomacanthidae	*Pomacanthus semicirculatus*	0.00008	0.059
Pomacanthidae	*Pomacanthus xanthometopon*	0.00025	0.078
Pomacanthidae	*Pygoplites diacanthus*	0.00333	0.406
Scaridae	*Bolbometopon muricatum*	0.00008	0.321
Scaridae	*Cetoscarus bicolor*	0.00150	0.873
Scaridae	*Chlorurus bleekeri*	0.00775	3.390
Scaridae	*Chlorurus japanensis*	0.00017	0.091
Scaridae	*Chlorurus microrhinos*	0.00108	1.011
Scaridae	*Chlorurus sordidus*	0.01539	3.819
Scaridae	*Scarus altipinnis*	0.00042	0.290
Scaridae	*Scarus dimidiatus*	0.01350	3.641
Scaridae	*Scarus flavipectoralis*	0.00408	1.701
Scaridae	*Scarus forsteni*	0.00083	0.290
Scaridae	*Scarus frenatus*	0.00142	0.524
Scaridae	*Scarus ghobban*	0.00108	0.912
Scaridae	*Scarus globiceps*	0.01108	4.230
Scaridae	*Scarus longipinnis*	0.00117	0.416
Scaridae	*Scarus niger*	0.00758	3.129
Scaridae	*Scarus oviceps*	0.00408	1.618
Scaridae	*Scarus psittacus*	0.03775	8.268
Scaridae	*Scarus rubroviolaceus*	0.00033	0.306
Scaridae	*Scarus schlegeli*	0.00825	1.404

3.1.2 Weighted average density and biomass of all finfish species recorded in Nggela (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus* spp.	0.00008	0.045
Scaridae	*Scarus spinus*	0.00350	1.076
Scaridae	*Scarus tricolor*	0.00008	0.045
Serranidae	*Aethaloperca rogaa*	0.00033	0.052
Serranidae	*Anyperodon leucogrammicus*	0.00108	0.312
Serranidae	*Cephalopholis argus*	0.00017	0.121
Serranidae	*Cephalopholis cyanostigma*	0.00546	1.759
Serranidae	*Cephalopholis urodeta*	0.00175	0.169
Serranidae	*Cromileptes altivelis*	0.00083	0.045
Serranidae	*Epinephelus areolatus*	0.00008	0.025
Serranidae	*Epinephelus coeruleopunctatus*	0.00017	0.084
Serranidae	*Epinephelus cyanopodus*	0.00008	0.054
Serranidae	*Epinephelus fasciatus*	0.00050	0.136
Serranidae	*Epinephelus merra*	0.00017	0.010
Serranidae	*Plectropomus areolatus*	0.00158	0.822
Serranidae	*Plectropomus leopardus*	0.00025	0.152
Serranidae	*Plectropomus maculatus*	0.00008	0.036
Serranidae	*Variola albimarginata*	0.00008	0.074
Serranidae	*Variola louti*	0.00025	0.186
Siganidae	*Siganus argenteus*	0.00483	1.017
Siganidae	*Siganus corallinus*	0.00183	1.299
Siganidae	*Siganus doliatus*	0.00375	1.034
Siganidae	*Siganus puellus*	0.00508	1.533
Siganidae	*Siganus punctatissimus*	0.00183	0.989
Siganidae	*Siganus spinus*	0.01533	1.425
Siganidae	*Siganus vermiculatus*	0.00033	0.230
Siganidae	*Siganus vulpinus*	0.00325	0.864
Sphyraenidae	*Sphyraena barracuda*	0.00517	1.833
Sphyraenidae	*Sphyraena forsteri*	0.00313	1.974
Zanclidae	*Zanclus cornutus*	0.00717	0.651

3.2 Marau finfish survey data

3.2.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Marau

Station name	Habitat	Latitude	Longitude
TRA01	Lagoon	9°51'30.6612" S	160°51'31.68" E
TRA02	Back-reef	9°51'35.1" S	160°52'17.6412" E
TRA03	Lagoon	9°50'47.2812" S	160°51'03.24" E
TRA04	Coastal reef	9°51'49.14" S	160°50'31.8012" E
TRA05	Coastal reef	9°51'23.1588" S	160°49'51.8412" E
TRA06	Coastal reef	9°51'17.5212" S	160°50'08.34" E
TRA07	Coastal reef	9°50'55.0788" S	160°50'01.2012" E
TRA08	Coastal reef	9°50'43.7388" S	160°49'52.86" E
TRA09	Coastal reef	9°50'40.3188" S	160°49'42.4812" E
TRA10	Lagoon	9°48'25.56" S	160°50'15.9612" E
TRA11	Lagoon	9°49'20.3412" S	160°50'56.8212" E
TRA12	Outer reef	9°46'56.7588" S	160°52'06.42" E
TRA13	Back-reef	9°46'59.2212" S	160°51'16.8588" E
TRA14	Back-reef	9°47'21.12" S	160°52'18.7212" E
TRA15	Lagoon	9°47'08.7" S	160°51'15.9012" E
TRA16	Back-reef	9°51'29.8188" S	160°53'14.7588" E
TRA17	Outer reef	9°51'11.7612" S	160°54'24.7212" E
TRA18	Back-reef	9°50'47.8212" S	160°54'16.9812" E
TRA19	Outer reef	9°50'49.0812" S	160°53'25.9188" E
TRA20	Outer reef	9°50'19.2588" S	160°53'39.7212" E
TRA21	Outer reef	9°49'21.8388" S	160°54'15.5988" E
TRA22	Outer reef	9°49'23.7" S	160°54'02.52" E
TRA23	Back-reef	9°52'03.54" S	160°53'04.8588" E
TRA24	Lagoon	9°50'47.1588" S	160°52'02.8812" E

3.2.2 Weighted average density and biomass of all finfish species recorded in Marau (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	0.01362	12.714
Acanthuridae	*Acanthurus guttatus*	0.00001	0.005
Acanthuridae	*Acanthurus lineatus*	0.03099	8.898
Acanthuridae	*Acanthurus mata*	0.01263	17.645
Acanthuridae	*Acanthurus nigricans*	0.00046	0.114
Acanthuridae	*Acanthurus nigricauda*	0.00342	3.034
Acanthuridae	*Acanthurus olivaceus*	0.01754	4.096
Acanthuridae	*Acanthurus pyroferus*	0.01823	3.286
Acanthuridae	*Acanthurus* spp.	0.00017	0.011
Acanthuridae	*Acanthurus thompsoni*	0.00022	0.016
Acanthuridae	*Acanthurus triostegus*	0.01328	0.977
Acanthuridae	*Acanthurus xanthopterus*	0.00478	5.282
Acanthuridae	*Ctenochaetus striatus*	0.10629	8.901
Acanthuridae	*Ctenochaetus tominiensis*	0.00031	0.013
Acanthuridae	*Naso annulatus*	0.00143	1.025
Acanthuridae	*Naso brachycentron*	0.00013	0.113
Acanthuridae	*Naso brevirostris*	0.00008	0.092

3.2.2 Weighted average density and biomass of all finfish species recorded in Marau (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso caesius*	0.00062	0.497
Acanthuridae	*Naso lituratus*	0.00293	1.456
Acanthuridae	*Naso tuberosus*	0.00059	0.750
Acanthuridae	*Naso unicornis*	0.00020	0.255
Acanthuridae	*Naso vlamingii*	0.00350	3.023
Acanthuridae	*Zebrasoma scopas*	0.01255	0.472
Acanthuridae	*Zebrasoma veliferum*	0.00062	0.052
Balistidae	*Balistapus undulatus*	0.01276	2.534
Balistidae	*Balistoides conspicillum*	0.00029	0.325
Balistidae	*Balistoides viridescens*	0.00084	1.035
Balistidae	*Melichthys niger*	0.01854	9.015
Balistidae	*Melichthys vidua*	0.00678	2.282
Balistidae	*Odonus niger*	0.01297	0.679
Balistidae	*Pseudobalistes flavimarginatus*	0.00089	1.681
Balistidae	*Rhinecanthus verrucosus*	0.00098	0.096
Balistidae	*Sufflamen bursa*	0.00117	0.167
Balistidae	*Sufflamen chrysopterum*	0.00562	0.750
Caesionidae	*Caesio caerulaurea*	0.00919	3.581
Caesionidae	*Caesio cuning*	0.02498	7.123
Caesionidae	*Pterocaesio pisang*	0.00210	0.183
Caesionidae	*Pterocaesio tile*	0.07201	8.623
Caesionidae	*Pterocaesio trilineata*	0.00156	0.091
Carangidae	*Carangoides chrysophrys*	0.00023	0.153
Carangidae	*Carangoides ferdau*	0.00305	2.118
Carangidae	*Carangoides orthogrammus*	0.00008	0.047
Carangidae	*Caranx melampygus*	0.00509	3.939
Carangidae	*Caranx sexfasciatus*	0.00011	0.192
Carangidae	*Decapterus russelli*	0.00074	0.144
Carangidae	*Elagatis bipinnulata*	0.00050	0.394
Carangidae	*Scomberoides lysan*	0.00006	0.004
Carcharhinidae	*Carcharhinus melanopterus*	0.00020	1.982
Chaetodontidae	*Chaetodon baronessa*	0.00552	0.163
Chaetodontidae	*Chaetodon bennetti*	0.00017	0.008
Chaetodontidae	*Chaetodon citrinellus*	0.00669	0.127
Chaetodontidae	*Chaetodon ephippium*	0.00082	0.038
Chaetodontidae	*Chaetodon kleinii*	0.00642	0.156
Chaetodontidae	*Chaetodon lineolatus*	0.00033	0.029
Chaetodontidae	*Chaetodon lunula*	0.00031	0.012
Chaetodontidae	*Chaetodon lunulatus*	0.00547	0.168
Chaetodontidae	*Chaetodon melannotus*	0.00015	0.005
Chaetodontidae	*Chaetodon meyeri*	0.00060	0.026
Chaetodontidae	*Chaetodon ornatissimus*	0.00115	0.044
Chaetodontidae	*Chaetodon pelewensis*	0.00050	0.018
Chaetodontidae	*Chaetodon rafflesii*	0.00260	0.084
Chaetodontidae	*Chaetodon* spp.	0.00001	0.000
Chaetodontidae	*Chaetodon speculum*	0.00011	0.006
Chaetodontidae	*Chaetodon trifascialis*	0.00136	0.026

3.2.2 Weighted average density and biomass of all finfish species recorded in Marau (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon ulietensis*	0.00048	0.014
Chaetodontidae	*Chaetodon unimaculatus*	0.00137	0.070
Chaetodontidae	*Chaetodon vagabundus*	0.00875	0.296
Chaetodontidae	*Forcipiger longirostris*	0.00201	0.110
Chaetodontidae	*Heniochus acuminatus*	0.00045	0.025
Chaetodontidae	*Heniochus chrysostomus*	0.00065	0.054
Chaetodontidae	*Heniochus varius*	0.00313	0.227
Ephippidae	*Platax* spp.	0.00002	0.015
Haemulidae	*Diagramma pictum*	0.00001	0.011
Haemulidae	*Plectorhinchus gibbosus*	0.00232	2.914
Haemulidae	*Plectorhinchus lineatus*	0.00015	0.201
Haemulidae	*Plectorhinchus orientalis*	0.00046	0.321
Holocentridae	*Myripristis adusta*	0.00121	0.396
Holocentridae	*Myripristis berndti*	0.02125	5.902
Holocentridae	*Myripristis violacea*	0.00039	0.041
Holocentridae	*Neoniphon sammara*	0.00590	0.747
Holocentridae	*Sargocentron caudimaculatum*	0.00151	0.216
Holocentridae	*Sargocentron diadema*	0.00078	0.085
Holocentridae	*Sargocentron spiniferum*	0.00020	0.169
Kyphosidae	*Kyphosus vaigiensis*	0.00104	0.477
Labridae	*Cheilinus chlorourus*	0.00270	0.359
Labridae	*Cheilinus fasciatus*	0.00172	0.678
Labridae	*Cheilinus trilobatus*	0.00026	0.011
Labridae	*Cheilinus undulatus*	0.00075	0.844
Labridae	*Choerodon anchorago*	0.00054	0.428
Labridae	*Coris aygula*	0.00008	0.015
Labridae	*Hemigymnus fasciatus*	0.00015	0.024
Labridae	*Hemigymnus melapterus*	0.00240	0.397
Lethrinidae	*Gnathodentex aureolineatus*	0.01485	5.481
Lethrinidae	*Gymnocranius euanus*	0.00006	0.055
Lethrinidae	*Lethrinus amboinensis*	0.00001	0.004
Lethrinidae	*Lethrinus genivittatus*	0.00001	0.000
Lethrinidae	*Lethrinus harak*	0.00098	0.462
Lethrinidae	*Lethrinus obsoletus*	0.00176	0.836
Lethrinidae	*Lethrinus olivaceus*	0.00115	1.220
Lethrinidae	*Lethrinus* spp.	0.00059	0.407
Lethrinidae	*Lethrinus xanthochilus*	0.00033	0.373
Lethrinidae	*Monotaxis grandoculis*	0.02240	15.471
Lutjanidae	*Aphareus furca*	0.00270	1.686
Lutjanidae	*Aprion virescens*	0.00020	0.223
Lutjanidae	*Lutjanus bohar*	0.00346	2.741
Lutjanidae	*Lutjanus fulviflamma*	0.00039	0.153
Lutjanidae	*Lutjanus fulvus*	0.00162	0.857
Lutjanidae	*Lutjanus gibbus*	0.03557	24.135
Lutjanidae	*Lutjanus kasmira*	0.00723	3.091
Lutjanidae	*Lutjanus lutjanus*	0.01990	3.846
Lutjanidae	*Lutjanus monostigma*	0.00378	3.231

3.2.2 Weighted average density and biomass of all finfish species recorded in Marau (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus rivulatus*	0.00023	0.317
Lutjanidae	*Lutjanus semicinctus*	0.00150	0.430
Lutjanidae	*Lutjanus vitta*	0.00002	0.014
Lutjanidae	*Macolor macularis*	0.00669	5.761
Lutjanidae	*Macolor niger*	0.00110	0.280
Mullidae	*Mulloidichthys flavolineatus*	0.02383	5.803
Mullidae	*Mulloidichthys vanicolensis*	0.01233	7.391
Mullidae	*Parupeneus barberinus*	0.00503	2.461
Mullidae	*Parupeneus cyclostomus*	0.00331	1.305
Mullidae	*Parupeneus multifasciatus*	0.01282	0.874
Mullidae	*Parupeneus pleurostigma*	0.00016	0.009
Nemipteridae	*Scolopsis bilineata*	0.00921	1.500
Nemipteridae	*Scolopsis ciliata*	0.00005	0.005
Nemipteridae	*Scolopsis margaritifera*	0.00087	0.353
Nemipteridae	*Scolopsis* spp.	0.00098	0.168
Nemipteridae	*Scolopsis temporalis*	0.00419	1.113
Nemipteridae	*Scolopsis trilineata*	0.00127	0.337
Pomacanthidae	*Apolemichthys trimaculatus*	0.00130	0.058
Pomacanthidae	*Centropyge bicolor*	0.00551	0.098
Pomacanthidae	*Centropyge bispinosa*	0.00006	0.001
Pomacanthidae	*Centropyge vrolikii*	0.00682	0.108
Pomacanthidae	*Pomacanthus navarchus*	0.00012	0.034
Pomacanthidae	*Pomacanthus semicirculatus*	0.00015	0.090
Pomacanthidae	*Pygoplites diacanthus*	0.00366	0.502
Scaridae	*Cetoscarus bicolor*	0.00045	0.268
Scaridae	*Chlorurus bleekeri*	0.00177	0.693
Scaridae	*Chlorurus japanensis*	0.00029	0.141
Scaridae	*Chlorurus microrhinos*	0.00061	0.694
Scaridae	*Chlorurus sordidus*	0.01666	4.401
Scaridae	*Scarus altipinnis*	0.00002	0.020
Scaridae	*Scarus dimidiatus*	0.00544	1.418
Scaridae	*Scarus flavipectoralis*	0.00164	0.679
Scaridae	*Scarus forsteni*	0.00001	0.006
Scaridae	*Scarus frenatus*	0.00006	0.003
Scaridae	*Scarus ghobban*	0.00057	0.541
Scaridae	*Scarus globiceps*	0.00162	0.630
Scaridae	*Scarus niger*	0.00306	1.451
Scaridae	*Scarus oviceps*	0.00244	0.696
Scaridae	*Scarus psittacus*	0.02315	4.461
Scaridae	*Scarus rubroviolaceus*	0.00020	0.141
Scaridae	*Scarus schlegeli*	0.00221	0.592
Scaridae	*Scarus spinus*	0.00246	0.735
Serranidae	*Aethaloperca rogaa*	0.00052	0.055
Serranidae	*Anyperodon leucogrammicus*	0.00047	0.164
Serranidae	*Cephalopholis argus*	0.00008	0.049
Serranidae	*Cephalopholis boenak*	0.00020	0.042
Serranidae	*Cephalopholis cyanostigma*	0.00108	0.483

3.2.2 Weighted average density and biomass of all finfish species recorded in Marau (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Serranidae	*Cephalopholis miniata*	0.00140	0.668
Serranidae	*Cephalopholis urodeta*	0.00574	0.686
Serranidae	*Epinephelus coioides*	0.00020	0.007
Serranidae	*Epinephelus cyanopodus*	0.00052	0.237
Serranidae	*Epinephelus fasciatus*	0.00055	0.072
Serranidae	*Epinephelus macrospilos*	0.00098	0.790
Serranidae	*Epinephelus maculatus*	0.00195	0.923
Serranidae	*Epinephelus merra*	0.00100	0.098
Serranidae	*Epinephelus spilotoceps*	0.00006	0.006
Serranidae	*Gracila albomarginata*	0.00031	0.167
Serranidae	*Plectropomus areolatus*	0.00019	0.064
Serranidae	*Plectropomus laevis*	0.00001	0.007
Serranidae	*Variola albimarginata*	0.00034	0.127
Serranidae	*Variola louti*	0.00074	0.714
Siganidae	*Siganus argenteus*	0.00264	1.351
Siganidae	*Siganus corallinus*	0.00055	0.407
Siganidae	*Siganus doliatus*	0.00115	0.408
Siganidae	*Siganus fuscescens*	0.00093	0.433
Siganidae	*Siganus puellus*	0.00162	0.672
Siganidae	*Siganus punctatissimus*	0.00077	0.416
Siganidae	*Siganus spinus*	0.00400	0.297
Siganidae	*Siganus vermiculatus*	0.00010	0.060
Siganidae	*Siganus vulpinus*	0.00087	0.232
Sphyraenidae	*Sphyraena barracuda*	0.00002	0.012
Zanclidae	*Zanclus cornutus*	0.00344	0.280

3.3 Rarumana finfish survey data

3.3.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Rarumana

Station name	Habitat	Latitude	Longitude
TRA01	Back-reef	8°13'09.9012" S	157°00'07.3188" E
TRA02	Lagoon	8°10'31.44" S	157°00'22.14" E
TRA03	Back-reef	8°09'44.82" S	157°00'30.78" E
TRA04	Outer reef	8°09'25.1388" S	157°00'28.1988" E
TRA05	Outer reef	8°10'02.64" S	156°59'06.9612" E
TRA06	Lagoon	8°09'21.5388" S	157°02'45.4812" E
TRA07	Back-reef	8°08'55.9212" S	157°02'54.1212" E
TRA08	Outer reef	8°08'51.1188" S	157°01'20.5212" E
TRA09	Outer reef	8°09'07.74" S	157°00'54.4212" E
TRA10	Lagoon	8°10'53.76" S	156°59'40.6788" E
TRA11	Lagoon	8°10'44.6988" S	156°59'02.22" E
TRA12	Back-reef	8°11'14.0388" S	156°57'39.6612" E
TRA13	Coastal reef	8°11'31.4412" S	157°00'12.96" E
TRA14	Coastal reef	8°11'17.6388" S	157°00'30.78" E
TRA15	Outer reef	8°12'13.7988" S	156°57'45.1188" E
TRA16	Outer reef	8°11'30.3612" S	156°57'30.3588" E
TRA17	Coastal reef	8°11'04.56" S	157°00'45.7812" E
TRA18	Lagoon	8°11'49.8012" S	157°00'00.36" E
TRA19	Coastal reef	8°12'13.7412" S	157°00'27.7812" E
TRA20	Back-reef	8°13'17.1588" S	157°00'44.1" E
TRA21	Lagoon	8°13'16.5" S	157°01'13.5588" E
TRA22	Coastal reef	8°13'24.06" S	157°01'47.64" E
TRA23	Back-reef	8°12'52.6212" S	156°58'29.5212" E
TRA24	Coastal reef	8°12'37.6812" S	157°01'02.2188" E

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.00002	0.002
Acanthuridae	*Acanthurus blochii*	0.01189	6.744
Acanthuridae	*Acanthurus guttatus*	0.00097	0.163
Acanthuridae	*Acanthurus lineatus*	0.00197	0.423
Acanthuridae	*Acanthurus mata*	0.00378	2.101
Acanthuridae	*Acanthurus nigricans*	0.00015	0.018
Acanthuridae	*Acanthurus nigricauda*	0.00238	0.717
Acanthuridae	*Acanthurus nigroris*	0.00118	0.090
Acanthuridae	*Acanthurus olivaceus*	0.00143	0.505
Acanthuridae	*Acanthurus pyroferus*	0.01137	1.401
Acanthuridae	*Acanthurus thompsoni*	0.00009	0.007
Acanthuridae	*Acanthurus triostegus*	0.00081	0.077
Acanthuridae	*Acanthurus xanthopterus*	0.00014	0.106
Acanthuridae	*Ctenochaetus striatus*	0.03517	2.746
Acanthuridae	*Ctenochaetus strigosus*	0.00019	0.005
Acanthuridae	*Ctenochaetus tominiensis*	0.00247	0.094

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso annulatus*	0.00043	0.154
Acanthuridae	*Naso brevirostris*	0.00007	0.035
Acanthuridae	*Naso hexacanthus*	0.00031	0.161
Acanthuridae	*Naso lituratus*	0.00441	2.277
Acanthuridae	*Naso* spp.	0.00016	0.037
Acanthuridae	*Naso thynnoides*	0.00008	0.091
Acanthuridae	*Naso unicornis*	0.00003	0.020
Acanthuridae	*Naso vlamingii*	0.00016	0.114
Acanthuridae	*Paracanthurus hepatus*	0.00016	0.009
Acanthuridae	*Zebrasoma scopas*	0.02635	1.012
Acanthuridae	*Zebrasoma veliferum*	0.00109	0.085
Balistidae	*Balistapus undulatus*	0.01092	1.579
Balistidae	*Balistoides conspicillum*	0.00020	0.281
Balistidae	*Balistoides viridescens*	0.00042	0.254
Balistidae	*Melichthys vidua*	0.00046	0.050
Balistidae	*Pseudobalistes flavimarginatus*	0.00008	0.088
Balistidae	*Rhinecanthus aculeatus*	0.00023	0.048
Balistidae	*Rhinecanthus verrucosus*	0.00003	0.003
Balistidae	*Sufflamen bursa*	0.00068	0.097
Balistidae	*Sufflamen chrysopterum*	0.00162	0.149
Caesionidae	*Caesio caerulaurea*	0.00202	0.479
Caesionidae	*Caesio cuning*	0.06204	8.820
Caesionidae	*Caesio teres*	0.02634	8.380
Caesionidae	*Pterocaesio tile*	0.01885	0.600
Carangidae	*Carangoides bajad*	0.00005	0.023
Carangidae	*Carangoides ferdau*	0.00070	0.448
Carangidae	*Caranx melampygus*	0.00367	1.745
Carangidae	*Caranx papuensis*	0.00027	0.152
Carangidae	*Caranx sexfasciatus*	0.00028	0.353
Carangidae	*Caranx* spp.	0.00004	0.027
Carangidae	*Elagatis bipinnulata*	0.00004	0.064
Carangidae	*Gnathanodon speciosus*	0.00016	0.167
Carangidae	*Scomberoides commersonnianus*	0.00004	0.041
Carangidae	*Scomberoides* spp.	0.00002	0.007
Carangidae	*Seriola* spp.	0.00002	0.409
Carcharhinidae	*Carcharhinus amblyrhynchos*	0.00006	2.356
Carcharhinidae	*Carcharhinus melanopterus*	0.00024	5.205
Carcharhinidae	*Triaenodon obesus*	0.00004	0.910
Chaetodontidae	*Chaetodon auriga*	0.00118	0.054
Chaetodontidae	*Chaetodon baronessa*	0.01043	0.287
Chaetodontidae	*Chaetodon bennetti*	0.00206	0.128
Chaetodontidae	*Chaetodon citrinellus*	0.00182	0.039
Chaetodontidae	*Chaetodon ephippium*	0.00544	0.246
Chaetodontidae	*Chaetodon kleinii*	0.00163	0.039
Chaetodontidae	*Chaetodon lineolatus*	0.00013	0.008
Chaetodontidae	*Chaetodon lunula*	0.00060	0.058
Chaetodontidae	*Chaetodon lunulatus*	0.01108	0.308

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon melannotus*	0.00053	0.011
Chaetodontidae	*Chaetodon meyeri*	0.00101	0.018
Chaetodontidae	*Chaetodon octofasciatus*	0.00047	0.016
Chaetodontidae	*Chaetodon ornatissimus*	0.00065	0.029
Chaetodontidae	*Chaetodon pelewensis*	0.00012	0.002
Chaetodontidae	*Chaetodon rafflesii*	0.00206	0.064
Chaetodontidae	*Chaetodon semeion*	0.00026	0.009
Chaetodontidae	*Chaetodon* spp.	0.00030	0.009
Chaetodontidae	*Chaetodon speculum*	0.00020	0.008
Chaetodontidae	*Chaetodon trifascialis*	0.00802	0.140
Chaetodontidae	*Chaetodon ulietensis*	0.00327	0.089
Chaetodontidae	*Chaetodon vagabundus*	0.00770	0.221
Chaetodontidae	*Coradion altivelis*	0.00020	0.009
Chaetodontidae	*Forcipiger flavissimus*	0.00026	0.007
Chaetodontidae	*Forcipiger longirostris*	0.00020	0.013
Chaetodontidae	*Heniochus acuminatus*	0.00189	0.131
Chaetodontidae	*Heniochus chrysostomus*	0.00181	0.107
Chaetodontidae	*Heniochus monoceros*	0.00019	0.018
Chaetodontidae	*Heniochus singularius*	0.00087	0.067
Chaetodontidae	*Heniochus varius*	0.00150	0.096
Diodontidae	*Diodon hystrix*	0.00045	0.119
Diodontidae	*Diodon* spp.	0.00002	0.018
Ephippidae	*Platax* spp.	0.00017	0.311
Ephippidae	*Platax teira*	0.00003	0.022
Haemulidae	*Plectorhinchus albovittatus*	0.00010	0.370
Haemulidae	*Plectorhinchus chaetodonoides*	0.00005	0.034
Haemulidae	*Plectorhinchus chrysotaenia*	0.00008	0.081
Haemulidae	*Plectorhinchus lineatus*	0.00008	0.062
Haemulidae	*Plectorhinchus orientalis*	0.00050	0.231
Holocentridae	*Myripristis adusta*	0.00350	0.445
Holocentridae	*Myripristis berndti*	0.00170	0.203
Holocentridae	*Myripristis murdjan*	0.00020	0.036
Holocentridae	*Neoniphon sammara*	0.00680	0.514
Holocentridae	*Sargocentron caudimaculatum*	0.00020	0.048
Holocentridae	*Sargocentron spiniferum*	0.00138	0.574
Kyphosidae	*Kyphosus cinerascens*	0.00020	0.115
Kyphosidae	*Kyphosus* spp.	0.00003	0.019
Labridae	*Cheilinus chlorourus*	0.00063	0.054
Labridae	*Cheilinus fasciatus*	0.00295	0.573
Labridae	*Cheilinus trilobatus*	0.00050	0.064
Labridae	*Cheilinus undulatus*	0.00044	0.254
Labridae	*Choerodon anchorago*	0.00398	1.491
Labridae	*Hemigymnus fasciatus*	0.00011	0.016
Labridae	*Hemigymnus melapterus*	0.00308	0.349
Lethrinidae	*Gnathodentex aureolineatus*	0.00079	0.101
Lethrinidae	*Lethrinus amboinensis*	0.00005	0.012
Lethrinidae	*Lethrinus erythracanthus*	0.00008	0.004

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lethrinidae	*Lethrinus erythropterus*	0.00056	0.092
Lethrinidae	*Lethrinus genivittatus*	0.00007	0.011
Lethrinidae	*Lethrinus harak*	0.00124	0.387
Lethrinidae	*Lethrinus olivaceus*	0.00036	0.155
Lethrinidae	*Lethrinus xanthochilus*	0.00039	0.259
Lethrinidae	*Monotaxis grandoculis*	0.01912	4.433
Lutjanidae	*Aphareus furca*	0.00010	0.053
Lutjanidae	*Aprion virescens*	0.00007	0.029
Lutjanidae	*Lutjanus biguttatus*	0.00210	0.237
Lutjanidae	*Lutjanus bohar*	0.00181	1.037
Lutjanidae	*Lutjanus carponotatus*	0.00124	0.500
Lutjanidae	*Lutjanus fulviflamma*	0.00020	0.051
Lutjanidae	*Lutjanus fulvus*	0.00005	0.008
Lutjanidae	*Lutjanus gibbus*	0.01017	3.501
Lutjanidae	*Lutjanus monostigma*	0.00038	0.214
Lutjanidae	*Lutjanus russellii*	0.00003	0.004
Lutjanidae	*Lutjanus semicinctus*	0.00300	0.861
Lutjanidae	*Lutjanus vitta*	0.00008	0.034
Lutjanidae	*Macolor macularis*	0.00423	1.780
Lutjanidae	*Macolor niger*	0.00108	0.352
Mullidae	*Mulloidichthys flavolineatus*	0.00164	0.090
Mullidae	*Parupeneus barberinus*	0.00530	0.786
Mullidae	*Parupeneus cyclostomus*	0.00226	0.532
Mullidae	*Parupeneus indicus*	0.00016	0.051
Mullidae	*Parupeneus multifasciatus*	0.00327	0.143
Mullidae	*Parupeneus pleurostigma*	0.00008	0.003
Nemipteridae	*Pentapodus* spp.	0.00146	0.176
Nemipteridae	*Scolopsis affinis*	0.00003	0.007
Nemipteridae	*Scolopsis bilineata*	0.00094	0.135
Nemipteridae	*Scolopsis ciliata*	0.00119	0.116
Nemipteridae	*Scolopsis lineata*	0.00199	0.166
Nemipteridae	*Scolopsis margaritifera*	0.00810	1.387
Nemipteridae	*Scolopsis* spp.	0.00008	0.023
Nemipteridae	*Scolopsis temporalis*	0.00313	0.708
Nemipteridae	*Scolopsis trilineata*	0.00291	0.236
Pomacanthidae	*Centropyge bicolor*	0.00078	0.028
Pomacanthidae	*Centropyge vrolikii*	0.00246	0.047
Pomacanthidae	*Chaetodontoplus melanosoma*	0.00016	0.004
Pomacanthidae	*Chaetodontoplus mesoleucus*	0.00590	0.151
Pomacanthidae	*Pomacanthus imperator*	0.00038	0.195
Pomacanthidae	*Pomacanthus navarchus*	0.00056	0.183
Pomacanthidae	*Pomacanthus semicirculatus*	0.00020	0.200
Pomacanthidae	*Pomacanthus sexstriatus*	0.00024	0.159
Pomacanthidae	*Pomacanthus xanthometopon*	0.00080	0.327
Pomacanthidae	*Pygoplites diacanthus*	0.00357	0.461
Scaridae	*Bolbometopon muricatum*	0.00033	0.567
Scaridae	*Cetoscarus bicolor*	0.00063	0.333

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus bleekeri*	0.00580	3.014
Scaridae	*Chlorurus japanensis*	0.00020	0.110
Scaridae	*Chlorurus microrhinos*	0.00020	0.170
Scaridae	*Chlorurus sordidus*	0.01773	4.649
Scaridae	*Hipposcarus longiceps*	0.00054	0.216
Scaridae	*Scarus chameleon*	0.00027	0.039
Scaridae	*Scarus dimidiatus*	0.01357	3.113
Scaridae	*Scarus flavipectoralis*	0.00484	0.997
Scaridae	*Scarus forsteni*	0.00004	0.020
Scaridae	*Scarus frenatus*	0.00024	0.051
Scaridae	*Scarus ghobban*	0.00311	1.755
Scaridae	*Scarus globiceps*	0.00386	0.847
Scaridae	*Scarus niger*	0.00201	0.798
Scaridae	*Scarus oviceps*	0.00915	3.946
Scaridae	*Scarus psittacus*	0.02422	5.262
Scaridae	*Scarus rivulatus*	0.00073	0.503
Scaridae	*Scarus rubroviolaceus*	0.00025	0.073
Scaridae	*Scarus schlegeli*	0.00041	0.157
Scaridae	*Scarus* spp.	0.00016	0.070
Scaridae	*Scarus spinus*	0.00030	0.102
Scaridae	*Scarus tricolor*	0.00020	0.134
Serranidae	*Aethaloperca rogaa*	0.00009	0.004
Serranidae	*Anyperodon leucogrammicus*	0.00171	0.320
Serranidae	*Cephalopholis argus*	0.00014	0.020
Serranidae	*Cephalopholis boenak*	0.00019	0.037
Serranidae	*Cephalopholis cyanostigma*	0.00146	0.300
Serranidae	*Cephalopholis microprion*	0.00024	0.014
Serranidae	*Cephalopholis miniata*	0.00016	0.066
Serranidae	*Cromileptes altivelis*	0.00016	0.069
Serranidae	*Epinephelus areolatus*	0.00008	0.026
Serranidae	*Epinephelus coeruleopunctatus*	0.00003	0.011
Serranidae	*Epinephelus coioides*	0.00044	0.164
Serranidae	*Epinephelus cyanopodus*	0.00007	0.026
Serranidae	*Epinephelus fasciatus*	0.00008	0.007
Serranidae	*Epinephelus fuscoguttatus*	0.00008	0.060
Serranidae	*Epinephelus maculatus*	0.00020	0.091
Serranidae	*Epinephelus merra*	0.00275	0.183
Serranidae	*Epinephelus ongus*	0.00008	0.013
Serranidae	*Epinephelus polyphekadion*	0.00028	0.215
Serranidae	*Epinephelus* spp.	0.00003	0.002
Serranidae	*Plectropomus areolatus*	0.00102	0.482
Serranidae	*Plectropomus leopardus*	0.00004	0.016
Serranidae	*Plectropomus maculatus*	0.00074	0.325
Serranidae	*Plectropomus oligacanthus*	0.00061	0.254
Siganidae	*Siganus corallinus*	0.00249	0.910
Siganidae	*Siganus doliatus*	0.00533	1.038
Siganidae	*Siganus lineatus*	0.00072	0.692

3.3.2 Weighted average density and biomass of all finfish species recorded in Rarumana (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Siganidae	*Siganus puellus*	0.00233	0.707
Siganidae	*Siganus punctatissimus*	0.00020	0.086
Siganidae	*Siganus spinus*	0.00042	0.026
Siganidae	*Siganus vulpinus*	0.00200	0.363
Zanclidae	*Zanclus cornutus*	0.00410	0.367

3.4 Chubikopi finfish survey data

3.4.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Chubikopi

Station name	Habitat	Latitude	Longitude
TRA01	Back-reef	8°27'45.2412" S	158°02'33.6588" E
TRA02	Lagoon	8°27'44.46" S	158°03'11.7612" E
TRA03	Lagoon	8°28'13.1988" S	158°03'35.5212" E
TRA04	Lagoon	8°28'52.68" S	158°03'23.1588" E
TRA05	Back-reef	8°27'50.58" S	158°01'36.0588" E
TRA06	Back-reef	8°26'20.22" S	157°58'58.0188" E
TRA07	Back-reef	8°26'14.1" S	157°58'20.28" E
TRA08	Back-reef	8°26'17.7" S	157°58'25.9212" E
TRA09	Lagoon	8°28'52.4388" S	158°01'39.18" E
TRA10	Outer reef	8°27'29.2212" S	158°03'31.2012" E
TRA11	Outer reef	8°27'35.28" S	158°02'28.9212" E
TRA12	Outer reef	8°27'35.8812" S	158°01'13.08" E
TRA13	Back-reef	8°26'19.6188" S	157°58'05.2788" E
TRA14	Outer reef	8°26'02.76" S	157°58'39.6012" E
TRA15	Outer reef	8°26'07.8" S	157°59'04.4412" E
TRA16	Outer reef	8°26'19.32" S	157°59'24.8388" E
TRA17	Lagoon	8°29'24.4788" S	157°59'44.9412" E
TRA18	Lagoon	8°28'34.9788" S	157°59'59.82" E
TRA19	Coastal reef	8°30'18.9" S	157°59'14.64" E
TRA20	Coastal reef	8°30'25.8012" S	157°59'00.1788" E
TRA21	Coastal reef	8°30'01.3788" S	158°00'30.5388" E
TRA22	Coastal reef	8°29'58.4412" S	158°00'16.3188" E
TRA23	Coastal reef	8°30'03.7188" S	157°59'57.5988" E
TRA24	Coastal reef	8°30'09.4212" S	157°59'35.7" E

3.4.2 Weighted average density and biomass of all finfish species recorded in Chubikopi (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	0.00002	0.002
Acanthuridae	*Acanthurus dussumieri*	0.00005	0.016
Acanthuridae	*Acanthurus lineatus*	0.00936	2.475
Acanthuridae	*Acanthurus maculiceps*	0.00018	0.076
Acanthuridae	*Acanthurus mata*	0.00001	0.002
Acanthuridae	*Acanthurus nigricauda*	0.00426	1.450
Acanthuridae	*Acanthurus nubilus*	0.00009	0.018
Acanthuridae	*Acanthurus pyroferus*	0.00409	1.098
Acanthuridae	*Acanthurus* spp.	0.00016	0.070
Acanthuridae	*Ctenochaetus binotatus*	0.00057	0.017
Acanthuridae	*Ctenochaetus striatus*	0.10215	13.551
Acanthuridae	*Ctenochaetus strigosus*	0.00057	0.015
Acanthuridae	*Ctenochaetus tominiensis*	0.00005	0.001
Acanthuridae	*Naso brevirostris*	0.00012	0.055
Acanthuridae	*Naso lituratus*	0.00079	0.438
Acanthuridae	*Naso* spp.	0.00005	0.010

3.4.2 Weighted average density and biomass of all finfish species recorded in Chubikopi (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso vlamingii*	0.00005	0.014
Acanthuridae	*Zebrasoma scopas*	0.01509	0.840
Acanthuridae	*Zebrasoma veliferum*	0.00278	0.304
Balistidae	*Balistapus undulatus*	0.00880	1.192
Balistidae	*Melichthys vidua*	0.00007	0.010
Balistidae	*Rhinecanthus rectangulus*	0.00005	0.004
Balistidae	*Sufflamen bursa*	0.00142	0.263
Balistidae	*Sufflamen chrysopterum*	0.00049	0.041
Belonidae	*Tylosurus crocodilus crocodilus*	0.00020	0.024
Caesionidae	*Caesio caerulaurea*	0.22688	68.835
Caesionidae	*Caesio cuning*	0.00582	1.115
Caesionidae	*Caesio* spp.	0.00349	0.182
Caesionidae	*Pterocaesio pisang*	0.00012	0.008
Caesionidae	*Pterocaesio tile*	0.00071	0.026
Carangidae	*Caranx melampygus*	0.00013	0.051
Carangidae	*Caranx* spp.	0.00002	0.003
Carcharhinidae	*Carcharhinus melanopterus*	0.00010	2.194
Carcharhinidae	*Triaenodon obesus*	0.00003	0.377
Chaetodontidae	*Chaetodon auriga*	0.00005	0.005
Chaetodontidae	*Chaetodon baronessa*	0.01137	0.440
Chaetodontidae	*Chaetodon bennetti*	0.00002	0.000
Chaetodontidae	*Chaetodon citrinellus*	0.00175	0.066
Chaetodontidae	*Chaetodon ephippium*	0.00338	0.473
Chaetodontidae	*Chaetodon kleinii*	0.00038	0.017
Chaetodontidae	*Chaetodon lineolatus*	0.00036	0.016
Chaetodontidae	*Chaetodon lunula*	0.00120	0.119
Chaetodontidae	*Chaetodon lunulatus*	0.01463	0.469
Chaetodontidae	*Chaetodon mertensii*	0.00002	0.001
Chaetodontidae	*Chaetodon octofasciatus*	0.00261	0.059
Chaetodontidae	*Chaetodon ornatissimus*	0.00033	0.021
Chaetodontidae	*Chaetodon pelewensis*	0.00009	0.002
Chaetodontidae	*Chaetodon plebeius*	0.00000	0.000
Chaetodontidae	*Chaetodon rafflesii*	0.00236	0.113
Chaetodontidae	*Chaetodon reticulatus*	0.00028	0.014
Chaetodontidae	*Chaetodon semeion*	0.00010	0.008
Chaetodontidae	*Chaetodon* spp.	0.00001	0.000
Chaetodontidae	*Chaetodon trifascialis*	0.00065	0.027
Chaetodontidae	*Chaetodon ulietensis*	0.00184	0.090
Chaetodontidae	*Chaetodon unimaculatus*	0.00007	0.006
Chaetodontidae	*Chaetodon vagabundus*	0.00655	0.533
Chaetodontidae	*Chelmon rostratus*	0.00057	0.022
Chaetodontidae	*Coradion altivelis*	0.00060	0.037
Chaetodontidae	*Forcipiger flavissimus*	0.00009	0.001
Chaetodontidae	*Forcipiger longirostris*	0.00061	0.019
Chaetodontidae	*Heniochus acuminatus*	0.00057	0.154
Chaetodontidae	*Heniochus chrysostomus*	0.00076	0.048
Chaetodontidae	*Heniochus monoceros*	0.00005	0.008

3.4.2 Weighted average density and biomass of all finfish species recorded in Chubikopi (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Heniochus varius*	0.00400	0.557
Haemulidae	*Plectorhinchus chaetodonoides*	0.00029	0.125
Holocentridae	*Myripristis adusta*	0.00033	0.059
Holocentridae	*Myripristis kuntee*	0.00066	0.052
Holocentridae	*Myripristis murdjan*	0.00012	0.020
Holocentridae	*Myripristis* spp.	0.00060	0.132
Holocentridae	*Myripristis violacea*	0.00279	0.312
Holocentridae	*Myripristis vittata*	0.00005	0.006
Holocentridae	*Neoniphon argenteus*	0.00145	0.059
Holocentridae	*Neoniphon opercularis*	0.00003	0.003
Holocentridae	*Neoniphon sammara*	0.00012	0.006
Holocentridae	*Neoniphon* spp.	0.00093	0.061
Holocentridae	*Sargocentron* spp.	0.00005	0.003
Holocentridae	*Sargocentron spiniferum*	0.00064	0.252
Holocentridae	*Sargocentron violaceum*	0.00000	0.001
Labridae	*Cheilinus chlorourus*	0.00005	0.006
Labridae	*Cheilinus fasciatus*	0.00219	0.305
Labridae	*Cheilinus trilobatus*	0.00002	0.001
Labridae	*Cheilinus undulatus*	0.00002	0.004
Labridae	*Choerodon anchorago*	0.00235	0.541
Labridae	*Epibulus insidiator*	0.00061	0.097
Labridae	*Hemigymnus fasciatus*	0.00000	0.000
Labridae	*Hemigymnus melapterus*	0.00033	0.032
Lethrinidae	*Gnathodentex aureolineatus*	0.00028	0.049
Lethrinidae	*Gymnocranius* spp.	0.00007	0.030
Lethrinidae	*Lethrinus erythracanthus*	0.00031	0.113
Lethrinidae	*Lethrinus erythropterus*	0.00007	0.005
Lethrinidae	*Lethrinus harak*	0.00005	0.011
Lethrinidae	*Lethrinus* spp.	0.00028	0.087
Lethrinidae	*Monotaxis grandoculis*	0.01232	1.503
Lutjanidae	*Aphareus furca*	0.00005	0.011
Lutjanidae	*Lutjanus biguttatus*	0.00034	0.043
Lutjanidae	*Lutjanus bohar*	0.00033	0.093
Lutjanidae	*Lutjanus carponotatus*	0.00034	0.190
Lutjanidae	*Lutjanus fulvus*	0.00238	0.630
Lutjanidae	*Lutjanus gibbus*	0.00605	1.941
Lutjanidae	*Lutjanus monostigma*	0.00003	0.011
Lutjanidae	*Lutjanus semicinctus*	0.00165	0.271
Lutjanidae	*Macolor macularis*	0.00003	0.020
Mullidae	*Mulloidichthys flavolineatus*	0.00226	0.288
Mullidae	*Mulloidichthys vanicolensis*	0.00069	0.132
Mullidae	*Parupeneus barberinus*	0.00399	0.527
Mullidae	*Parupeneus cyclostomus*	0.00057	0.150
Mullidae	*Parupeneus indicus*	0.00002	0.005
Mullidae	*Parupeneus multifasciatus*	0.00225	0.190
Nemipteridae	*Pentapodus* spp.	0.00057	0.079
Nemipteridae	*Pentapodus trivittatus*	0.00430	0.488

3.4.2 Weighted average density and biomass of all finfish species recorded in Chubikopi (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Nemipteridae	*Scolopsis affinis*	0.00012	0.007
Nemipteridae	*Scolopsis bilineata*	0.00021	0.015
Nemipteridae	*Scolopsis ciliata*	0.00227	0.244
Nemipteridae	*Scolopsis lineata*	0.00444	0.348
Nemipteridae	*Scolopsis margaritifera*	0.00567	0.751
Nemipteridae	*Scolopsis* spp.	0.00025	0.010
Nemipteridae	*Scolopsis temporalis*	0.00057	0.027
Nemipteridae	*Scolopsis trilineata*	0.00002	0.001
Pomacanthidae	*Pomacanthus sexstriatus*	0.00028	0.122
Pomacanthidae	*Pygoplites diacanthus*	0.00309	0.468
Scaridae	*Bolbometopon muricatum*	0.00003	0.126
Scaridae	*Chlorurus bleekeri*	0.00652	1.253
Scaridae	*Chlorurus microrhinos*	0.00002	0.031
Scaridae	*Chlorurus sordidus*	0.00730	0.694
Scaridae	*Hipposcarus longiceps*	0.00241	0.861
Scaridae	*Scarus altipinnis*	0.00000	0.000
Scaridae	*Scarus chameleon*	0.00012	0.003
Scaridae	*Scarus dimidiatus*	0.03350	1.706
Scaridae	*Scarus flavipectoralis*	0.00446	0.305
Scaridae	*Scarus frenatus*	0.00059	0.147
Scaridae	*Scarus ghobban*	0.00059	0.090
Scaridae	*Scarus globiceps*	0.00047	0.129
Scaridae	*Scarus niger*	0.00135	0.271
Scaridae	*Scarus oviceps*	0.00237	0.346
Scaridae	*Scarus psittacus*	0.00611	0.273
Scaridae	*Scarus quoyi*	0.00066	0.087
Scaridae	*Scarus rivulatus*	0.00714	1.019
Scaridae	*Scarus* spp.	0.00311	0.397
Scaridae	*Scarus spinus*	0.00006	0.013
Scombridae	*Rastrelliger kanagurta*	0.00029	0.043
Serranidae	*Anyperodon leucogrammicus*	0.00031	0.124
Serranidae	*Cephalopholis boenak*	0.00199	0.256
Serranidae	*Cephalopholis cyanostigma*	0.00034	0.067
Serranidae	*Cephalopholis miniata*	0.00028	0.046
Serranidae	*Cephalopholis sexmaculata*	0.00005	0.010
Serranidae	*Cephalopholis urodeta*	0.00085	0.074
Serranidae	*Epinephelus areolatus*	0.00028	0.030
Serranidae	*Epinephelus cyanopodus*	0.00002	0.005
Serranidae	*Epinephelus maculatus*	0.00007	0.017
Serranidae	*Epinephelus merra*	0.00041	0.032
Serranidae	*Epinephelus sexfasciatus*	0.00002	0.004
Serranidae	*Gracila albomarginata*	0.00002	0.005
Serranidae	*Plectropomus areolatus*	0.00003	0.005
Serranidae	*Plectropomus oligacanthus*	0.00002	0.006
Siganidae	*Siganus corallinus*	0.00007	0.018
Siganidae	*Siganus doliatus*	0.00209	0.280
Siganidae	*Siganus fuscescens*	0.00003	0.005

3.4.2 Weighted average density and biomass of all finfish species recorded in Chubikopi (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Siganidae	*Siganus lineatus*	0.00131	0.562
Siganidae	*Siganus puellus*	0.00057	0.116
Siganidae	*Siganus punctatissimus*	0.00031	0.080
Siganidae	*Siganus punctatus*	0.00001	0.003
Siganidae	*Siganus vulpinus*	0.00005	0.009
Zanclidae	*Zanclus cornutus*	0.00236	0.371

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Nggela invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Nggela

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*		+		
Bêche-de-mer	*Actinopyga mauritiana*	+	+		+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+			+
Bêche-de-mer	*Bohadschia similis*		+	+	
Bêche-de-mer	*Bohadschia vitiensis*				+
Bêche-de-mer	*Holothuria atra*	+	+		+
Bêche-de-mer	*Holothuria coluber*		+		+
Bêche-de-mer	*Holothuria edulis*		+		+
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*		+		+
Bêche-de-mer	*Holothuria nobilis*	+			+
Bêche-de-mer	*Holothuria scabra*			+	
Bêche-de-mer	*Stichopus hermanni*	+			
Bêche-de-mer	*Stichopus horrens*				+
Bêche-de-mer	*Synapta* spp.		+		
Bêche-de-mer	*Thelenota ananas*	+			
Bêche-de-mer	*Thelenota anax*	+	+		+
Bivalve	*Atrina vexillum*	+			+
Bivalve	*Beguina semiorbiculata*	+	+		
Bivalve	*Chama* spp.	+	+		
Bivalve	*Hippopus hippopus*		+		
Bivalve	*Hyotissa* spp.	+	+		
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Pinctada* spp.		+		
Bivalve	*Pinna* spp.	+	+		
Bivalve	*Pteria* spp.		+		+
Bivalve	*Spondylus* spp.		+		
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna derasa*	+			+
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		+
Cnidarian	*Entacmaea quadricolor*	+	+		
Cnidarian	*Heteractis aurora*		+		
Cnidarian	*Heteractis* spp.				+
Cnidarian	*Stichodactyla gigantea*	+	+		
Cnidarian	*Stichodactyla* spp.	+	+	+	+
Crustacean	*Calappa* spp.				+
Crustacean	*Lysiosquillina maculata*	+			
Crustacean	*Panulirus versicolor*	+	+		
Crustacean	*Portunus* spp.		+		+
Crustacean	*Thalassina* spp.		+	+	
Gastropod	*Astralium* spp.	+	+	+	
Gastropod	*Cassis cornuta*				+

+ = presence of the species.

4.1.1 Invertebrate species recorded in different assessments in Nggela (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Cerithium aluco*	+			
Gastropod	*Cerithium nodulosum*		+	+	
Gastropod	*Chicoreus brunneus*		+		
Gastropod	*Chicoreus* spp.		+		
Gastropod	*Conus bandanus*		+		
Gastropod	*Conus distans*	+	+	+	+
Gastropod	*Conus ebraeus*			+	
Gastropod	*Conus generalis*			+	
Gastropod	*Conus imperialis*	+		+	
Gastropod	*Conus leopardus*	+	+	+	+
Gastropod	*Conus litteratus*	+	+	+	
Gastropod	*Conus lividus*		+		+
Gastropod	*Conus marmoreus*	+	+	+	+
Gastropod	*Conus miles*	+	+		+
Gastropod	*Conus pulicarius*		+		
Gastropod	*Conus* spp.	+	+		
Gastropod	*Conus textile*		+		
Gastropod	*Conus virgo*			+	
Gastropod	*Cymatium lotorium*		+		
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea arabica*		+		
Gastropod	*Cypraea erosa*	+	+		
Gastropod	*Cypraea moneta*			+	
Gastropod	*Cypraea* spp.		+		
Gastropod	*Cypraea tigris*	+	+		+
Gastropod	*Drupella* spp.		+		
Gastropod	*Lambis chiragra*	+	+		
Gastropod	*Lambis crocata*		+		
Gastropod	*Lambis lambis*	+	+	+	+
Gastropod	*Lambis scorpius*	+	+	+	
Gastropod	*Lambis* spp.		+		+
Gastropod	*Lambis truncata*	+			
Gastropod	*Latirolagena smaragdula*	+	+		
Gastropod	*Oliva* spp.			+	
Gastropod	*Pleuroploca filamentosa*	+	+		
Gastropod	*Pleuroploca* spp.		+		+
Gastropod	*Pleuroploca trapezium*				+
Gastropod	*Strombus luhuanus*	+	+	+	
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Thais armigera*		+		
Gastropod	*Thais* spp.	+	+	+	+
Gastropod	*Trochus maculata*	+	+		+
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Turbo argyrostomus*				+
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Turbo petholatus*		+		
Gastropod	*Turbo* spp.		+		
Gastropod	*Vasum ceramicum*	+	+		+

+ = presence of the species.

4.1.1 Invertebrate species recorded in different assessments in Nggela (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Star	*Acanthaster planci*	+	+		+
Star	*Choriaster granulatus*	+			+
Star	*Culcita novaeguineae*	+	+		+
Star	*Fromia* spp.		+		
Star	*Linckia guildingi*	+	+	+	+
Star	*Linckia laevigata*	+	+		+
Star	*Nardoa* spp.		+		
Star	*Protoreaster nodosus*	+	+		+
Urchin	*Diadema* spp.	+	+		+
Urchin	*Echinometra mathaei*	+	+	+	+
Urchin	*Echinothrix calamaris*		+		
Urchin	*Echinothrix diadema*	+	+	+	+
Urchin	*Heterocentrotus mammillatus*	+	+		
Urchin	*Heterocentrotus trigonarius*	+			
Urchin	*Mespilia globulus*			+	
Urchin	*Tripneustes gratilla*		+		+

+ = presence of the species.

4.1.2 Nggela broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	39.1	11.3	72	100.4	25.3	28	38.6	14.0	12	38.6	14.0	12
Actinopyga mauritiana	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Astralium spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Atrina vexillum	0.9	0.5	72	16.7	0.0	4	0.9	0.5	12	3.7	0.9	3
Beguina semiorbiculata	32.9	14.2	72	157.8	59.1	15	32.9	17.4	12	78.8	33.1	5
Bohadschia argus	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Bohadschia graeffei	3.2	1.9	72	33.3	16.7	7	3.2	2.1	12	9.7	5.1	4
Cerithium aluco	0.2	0.2	72	13.8		1	0.2	0.2	12	2.7		1
Chama spp.	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Choriaster granulatus	0.7	0.4	72	16.4	0.3	3	0.7	0.7	12	8.3		1
Conus distans	5.3	1.3	72	22.5	2.8	17	5.3	2.2	12	10.6	3.1	6
Conus imperialis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Conus leopardus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Conus litteratus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Conus marmoreus	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Conus miles	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Conus spp.	0.7	0.4	72	16.7	0.0	3	0.7	0.7	12	8.3		1
Culcita novaeguineae	4.8	1.6	72	24.9	6.0	14	4.8	2.4	12	6.4	3.0	9
Culcita spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Cypraea erosa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Cypraea tigris	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.7	0.0	2
Diadema spp.	325.0	162.6	72	2600.0	1067.2	9	325.0	304.4	12	1950.0	1716.7	2
Echinometra mathaei	56.8	11.2	72	116.9	18.3	35	56.7	17.1	12	68.1	18.5	10
Echinothrix diadema	221.7	104.3	72	798.2	349.6	20	221.7	174.5	12	532.1	399.7	5
Entacmaea quadricolor	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Heterocentrotus mammillatus	0.7	0.4	72	16.7	0.0	3	0.7	0.5	12	4.2	1.4	2
Heterocentrotus trigonarius	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Holothuria atra	2.8	0.9	72	20.0	2.2	10	2.7	0.9	12	4.7	1.1	7

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.2 Nggela broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Holothuria nobilis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Hyotissa spp.	1.4	1.0	72	50.0	16.7	2	1.4	1.4	12	16.7		1
Lambis chiragra	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.7	0.0	2
Lambis lambis	1.8	0.7	72	19.0	2.4	7	1.8	0.9	12	5.5	1.6	4
Lambis scorpius	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Lambis truncata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Latirolagena smaragdula	9.3	7.0	72	83.3	59.8	8	9.3	7.1	12	18.5	13.6	6
Linckia guildingi	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Linckia laevigata	114.3	16.3	72	139.4	18.3	59	114.3	21.3	12	114.3	21.3	12
Linckia spp.	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Lysiosquillina maculata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Panulirus versicolor	3.2	1.1	72	22.9	3.7	10	3.2	1.7	12	7.7	3.1	5
Pinctada margaritifera	1.8	0.8	72	26.5	4.0	5	1.8	1.0	12	5.5	2.0	4
Pinna spp.	0.5	0.5	72	33.3		1	0.5	0.5	12	5.6		1
Pleuroploca filamentosa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Protoreaster nodosus	1.2	0.8	72	41.7	8.3	2	1.2	0.8	12	6.9	1.4	2
Stichodactyla gigantea	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichodactyla spp.	17.1	4.6	72	39.7	9.4	31	17.1	7.7	12	17.1	7.7	12
Stichopus hermanni	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Strombus luhuanus	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Tectus pyramis	12.5	6.5	72	81.7	37.3	11	12.5	8.3	12	18.7	12.1	8
Thais spp.	3.0	1.0	72	21.7	3.6	10	3.0	1.5	12	7.2	2.6	5
Thelenota ananas	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Thelenota anax	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	5.1	1.3	72	24.4	2.8	15	5.1	1.5	12	7.6	1.6	8
Tridacna derasa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna maxima	6.3	1.3	72	20.5	1.9	22	6.2	1.6	12	8.3	1.5	9
Tridacna squamosa	1.2	0.5	72	16.7	0.0	5	1.2	0.5	12	3.5	0.7	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.2 Nggela broad-scale assessment data review (continued)
Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Trochus maculata	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Trochus niloticus	3.7	1.2	72	29.6	2.5	9	3.7	1.5	12	7.4	2.0	6
Vasum ceramicum	2.1	0.8	72	21.4	3.1	7	2.1	0.7	12	4.2	0.6	6

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Nggela reef-benthos transect (RBt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	500.0	99.0	78	1 026.3	165.2	38	500.0	210.4	13	590.9	239.5	11
Actinopyga lecanora	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Actinopyga mauritiana	6.4	4.5	78	250.0	0.0	2	6.4	6.4	13	83.3		1
Astralium spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Beguina semiorbiculata	44.9	24.9	78	700.0	266.9	5	44.9	29.6	13	194.4	91.1	3
Bohadschia argus	12.8	7.8	78	333.3	83.3	3	12.8	9.9	13	83.3	41.7	2
Cerithium nodulosum	12.8	10.1	78	500.0	250.0	2	12.8	9.9	13	83.3	41.7	2
Chama spp.	6.4	4.5	78	250.0	0.0	2	6.4	6.4	13	83.3		1
Chicoreus brunneus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Chicoreus spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus bandanus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus distans	25.6	11.7	78	333.3	83.3	6	25.6	16.0	13	83.3	41.7	4
Conus leopardus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus litteratus	25.6	14.1	78	400.0	150.0	5	25.6	13.0	13	66.7	25.0	5
Conus lividus	60.9	27.1	78	593.8	182.6	8	60.9	34.2	13	158.3	72.6	5
Conus marmoreus	25.6	10.8	78	333.3	52.7	6	25.6	10.1	13	66.7	10.2	5
Conus miles	44.9	17.5	78	500.0	77.2	7	44.9	22.4	13	145.8	39.9	4
Conus pulicarius	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Nggela reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Conus spp.	6.4	6.4	78	500.0		1	6.4	6.4	13	83.3		1
Conus textile	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Culcita novaeguineae	35.3	9.9	78	250.0	0.0	11	35.3	11.4	13	65.5	12.4	7
Cymatium lotorium	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea annulus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea arabica	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea erosa	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea tigris	35.3	14.2	78	392.9	74.3	7	35.3	22.6	13	114.6	59.8	4
Diadema spp.	256.4	103.4	78	1 538.5	497.5	13	256.4	142.4	13	476.2	240.5	7
Drupella spp.	99.4	58.8	78	1 937.5	738.6	4	99.4	86.4	13	645.8	479.2	2
Echinometra mathaei	1660.3	295.4	78	2 354.5	382.4	55	1 660.3	453.8	13	1 660.3	453.8	13
Echinothrix calamaris	9.6	5.5	78	250.0	0.0	3	9.6	5.1	13	41.7	0.0	3
Echinothrix diadema	1224.4	433.3	78	4 547.6	1 388.9	21	1 224.4	869.4	13	1 989.6	1 374.0	8
Entacmaea quadricolor	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Fromia spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Heteractis aurora	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Heterocentrotus mammillatus	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Hippopus hippopus	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Holothuria atra	28.8	10.2	78	281.3	31.3	8	28.8	9.9	13	62.5	9.3	6
Holothuria edulis	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Holothuria fuscopunctata	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Hyotissa spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Lambis chiragra	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Lambis crocata	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Lambis lambis	25.6	9.8	78	285.7	35.7	7	25.6	12.1	13	83.3	17.0	4
Lambis scorpius	9.6	5.5	78	250.0	0.0	3	9.6	5.1	13	41.7	0.0	3
Lambis spp.	22.4	12.2	78	437.5	119.7	4	22.4	16.8	13	145.8	62.5	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Nggela reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Latirolagena smaragdula	54.5	16.9	78	386.4	51.8	11	54.5	26.8	13	118.1	47.4	6
Linckia guildingi	12.8	7.8	78	333.3	83.3	3	12.8	9.9	13	83.3	41.7	2
Linckia laevigata	775.6	155.4	78	1 141.5	211.2	53	775.6	244.3	13	775.6	244.3	13
Nardoa spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Panulirus versicolor	9.6	5.5	78	250.0	0.0	3	9.6	5.1	13	41.7	0.0	3
Pinctada margaritifera	19.2	7.6	78	250.0	0.0	6	19.2	7.6	13	50.0	8.3	5
Pinctada spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Pinna spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Pleuroploca filamentosa	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Pleuroploca spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Portunus spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Pteria spp.	19.2	10.0	78	375.0	72.2	4	19.2	13.0	13	83.3	41.7	3
Spondylus spp.	12.8	6.3	78	250.0	0.0	4	12.8	5.6	13	41.7	0.0	4
Stichodactyla gigantea	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Stichodactyla spp.	182.7	54.5	78	750.0	168.8	19	182.7	104.4	13	296.9	159.7	8
Strombus luhuanus	19.2	8.9	78	300.0	50.0	5	19.2	9.0	13	62.5	12.0	4
Tectus pyramis	109.0	29.8	78	447.4	84.6	19	109.0	32.2	13	157.4	35.9	9
Thais armigera	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Thais spp.	44.9	14.2	78	318.2	48.7	11	44.9	13.7	13	72.9	15.2	8
Thalassina spp.	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Thelenota anax	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Tridacna crocea	96.2	21.5	78	357.1	44.2	21	96.2	36.0	13	125.0	43.0	10
Tridacna maxima	141.0	31.8	78	440.0	68.1	25	141.0	62.0	13	152.8	66.1	12
Tridacna squamosa	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Tripneustes gratilla	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Trochus maculata	57.7	15.1	78	321.4	31.3	14	57.7	22.9	13	107.1	32.6	7
Trochus niloticus	41.7	16.1	78	361.1	84.5	9	41.7	17.0	13	77.4	24.8	7
Turbo chrysostomus	41.7	12.4	78	295.5	30.5	11	41.7	16.3	13	90.3	22.6	6

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Nggela reef-benthos transect (RBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Turbo petholatus	19.2	7.6	78	250.0	0.0	6	19.2	7.6	13	50.0	8.3	5
Turbo spp.	9.6	7.1	78	375.0	125.0	2	9.6	6.9	13	62.5	20.8	2
Vasum ceramicum	32.1	10.6	78	277.8	27.8	9	32.1	10.7	13	59.5	12.4	7

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.4 Nggela soft-benthos transect (SBt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Astralium spp.	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Bohadschia similis	25.0	18.4	30	375.0	125.0	2	25.0	16.7	5	62.5	20.8	2
Cerithium nodulosum	16.7	11.6	30	250.0	0.0	2	16.7	16.7	5	83.3		1
Conus distans	16.7	11.6	30	250.0	0.0	2	16.7	10.2	5	41.7	0.0	2
Conus ebraeus	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Conus generalis	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Conus imperialis	16.7	16.7	30	500.0		1	16.7	16.7	5	83.3		1
Conus leopardus	16.7	11.6	30	250.0	0.0	2	16.7	10.2	5	41.7	0.0	2
Conus litteratus	325.0	86.6	30	609.4	124.9	16	325.0	116.7	5	325.0	116.7	5
Conus marmoreus	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Conus virgo	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Cypraea moneta	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Diadema spp.	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Echinometra mathaei	141.7	84.5	30	850.0	400.0	5	141.7	74.1	5	236.1	84.5	3
Echinothrix diadema	200.0	200.0	30	6000.0		1	200.0	200.0	5	1000.0		1
Holothuria coluber	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Holothuria scabra	25.0	18.4	30	375.0	125.0	2	25.0	16.7	5	62.5	20.8	2
Lambis lambis	16.7	11.6	30	250.0	0.0	2	16.7	10.2	5	41.7	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.4 Nggela soft-benthos transect (SBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Lambis scorpius	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Linckia guildingi	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Mespilia globulus	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Oliva spp.	25.0	25.0	30	750.0		1	25.0	25.0	5	125.0		1
Pinna spp.	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Protoreaster nodosus	33.3	33.3	30	1000.0		1	33.3	33.3	5	166.7		1
Stichodactyla spp.	75.0	45.1	30	562.5	236.6	4	75.0	55.0	5	125.0	83.3	3
Strombus luhuanus	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Synapta spp.	91.7	59.3	30	916.7	363.2	3	91.7	91.7	5	458.3		1
Thais spp.	91.7	83.5	30	1375.0	1125.0	2	91.7	91.7	5	458.3		1
Thalassina spp.	66.7	35.8	30	500.0	144.3	4	66.7	56.8	5	166.7	125.0	2
Tridacna crocea	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1
Tripneustes gratilla	8.3	8.3	30	250.0		1	8.3	8.3	5	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.5 Nggela mother-of-pearl transect (MOPt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	62.5	19.9	24	166.7	29.5	9	62.5	36.1	4	125.0	0.0	2
Actinopyga mauritiana	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Bohadschia argus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Bohadschia graeffei	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Conus distans	41.7	14.4	24	142.9	17.9	7	41.7	8.5	4	41.7	8.5	4
Conus lividus	10.4	10.4	24	250.0		1	10.4	10.4	4	41.7		1
Conus miles	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Culcita novaeguineae	46.9	12.6	24	125.0	0.0	9	46.9	10.0	4	46.9	10.0	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.5 Nggela mother-of-pearl transect (MOPt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Cypraea tigris	20.8	12.3	24	166.7	41.7	3	20.8	14.7	4	41.7	20.8	2
Echinometra mathaei	83.3	41.0	24	500.0	88.4	4	83.3	58.9	4	166.7	83.3	2
Echinothrix diadema	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Heteractis spp.	15.6	11.4	24	187.5	62.5	2	15.6	15.6	4	62.5		1
Holothuria atra	15.6	8.6	24	125.0	0.0	3	15.6	5.2	4	20.8	0.0	3
Lambis lambis	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Lambis spp.	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Linckia guildingi	41.7	14.4	24	142.9	17.9	7	41.7	19.0	4	55.6	18.4	3
Linckia laevigata	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Pinctada margaritifera	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Protoreaster nodosus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Stichodactyla spp.	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Tectus pyramis	93.8	25.2	24	204.5	30.5	11	93.8	47.0	4	93.8	47.0	4
Thais spp.	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Tridacna derasa	15.6	8.6	24	125.0	0.0	3	15.6	10.0	4	31.3	10.4	2
Tridacna maxima	62.5	18.4	24	166.7	20.8	9	62.5	24.1	4	62.5	24.1	4
Tridacna squamosa	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Tripneustes gratilla	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Trochus maculata	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Trochus niloticus	57.3	19.9	24	196.4	25.3	7	57.3	19.7	4	76.4	6.9	3
Turbo argyrostomus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Vasum ceramicum	15.6	11.4	24	187.5	62.5	2	15.6	10.0	4	31.3	10.4	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.6 Nggela sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Atrina vexillum	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Bohadschia vitiensis	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Calappa spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Conus distans	8.9	6.0	12	53.3	0.0	2	8.9	0.0	2	8.9	0.0	2
Conus leopardus	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Conus marmoreus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Culcita novaeguineae	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Diadema spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Echinometra mathaei	40.0	24.7	12	160.0	61.6	3	40.0	40.0	2	80.0		1
Echinothrix diadema	17.8	7.6	12	53.3	0.0	4	17.8	0.0	2	17.8	0.0	2
Heteractis spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Holothuria coluber	22.2	10.3	12	66.7	13.3	4	22.2	22.2	2	44.4		1
Holothuria nobilis	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Lambis lambis	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Linckia guildingi	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Linckia laevigata	128.9	45.2	12	171.9	53.2	9	128.9	40.0	2	128.9	40.0	2
Pleuroploca spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Pleuroploca trapezium	13.3	13.3	12	160.0		1	13.3	13.3	2	26.7		1
Portunus spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Protoreaster nodosus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Stichodactyla spp.	17.8	10.0	12	71.1	17.8	3	17.8	0.0	2	17.8	0.0	2
Stichopus horrens	13.3	13.3	12	160.0		1	13.3	13.3	2	26.7		1
Tectus pyramis	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Tridacna maxima	8.9	6.0	12	53.3	0.0	2	8.9	0.0	2	8.9	0.0	2
Tripneustes gratilla	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Trochus niloticus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.7 Nggela sea cucumber day search (Ds) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	3.6	3.6	24	85.7		1	3.6	3.6	4	14.3		1
Bohadschia argus	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Cassis cornuta	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Choriaster granulatus	10.7	3.2	24	28.6	3.6	9	10.7	2.5	4	10.7	2.5	4
Conus distans	4.5	4.5	24	107.1		1	4.5	4.5	4	17.8		1
Culcita novaeguineae	2.7	2.0	24	32.1	10.7	2	2.7	2.7	4	10.7		1
Culcita spp.	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Holothuria atra	5.4	2.3	24	25.7	4.3	5	5.4	3.1	4	7.1	3.6	3
Holothuria edulis	2.7	1.5	24	21.4	0.0	3	2.7	1.7	4	5.4	1.8	2
Holothuria fuscogilva	17.8	8.0	24	71.4	20.4	6	17.8	8.6	4	17.8	8.6	4
Holothuria fuscopunctata	1.8	1.2	24	21.4	0.0	2	1.8	1.0	4	3.6	0.0	2
Linckia guildingi	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Linckia laevigata	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Pinctada margaritifera	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Pteria spp.	1.8	1.8	24	42.8		1	1.8	1.8	4	7.1		1
Stichodactyla spp.	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Thelenota anax	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1
Tridacna crocea	0.9	0.9	24	21.4		1	0.9	0.9	4	3.6		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.8 Nggela species size review – all survey methods

Species	Mean length (cm)	SE	n
Tectus pyramis	56.9	1.9	107
Tridacna maxima	139.9	5.9	84
Latirolagena smaragdula	52.5	7.5	57
Tridacna crocea	80.3	4.4	54
Conus distans	86.1	3.4	48
Conus litteratus	57.4	2.8	48
Trochus niloticus	70.8	4.2	41
Holothuria atra	305.0	28.3	30
Vasum ceramicum	74.0	5.6	22
Trochus maculata	35.0	0.0	22
Conus lividus	42.5	7.5	21
Holothuria fuscogilva	341.9	17.4	20
Lambis lambis	138.0	9.7	20
Pinctada margaritifera	105.0	12.6	17
Cypraea tigris	71.4	2.2	17
Bohadschia graeffei	240.0	13.1	15
Turbo chrysostomus	39.0	1.0	13
Conus marmoreus	64.5	10.3	12
Bohadschia argus	262.2	21.7	9
Tridacna squamosa	193.3	23.8	9
Lambis spp.	110.0	8.9	8
Cerithium nodulosum	93.3	3.3	6
Conus leopardus	83.3	7.3	6
Tridacna derasa	167.5	34.7	4
Actinopyga mauritiana	143.3	8.8	4
Spondylus spp.	100.0	0.0	4
Thelenota ananas	450.0	76.4	3
Thelenota anax	390.0	210.0	3
Holothuria fuscopunctata	265.0	85.0	3
Bohadschia similis	156.7	32.8	3
Holothuria scabra	145.0	10.4	3
Conus imperialis	40.5	5.5	3
Bohadschia vitiensis	280.0	30.0	2
Holothuria nobilis	190.0	10.0	2
Hippopus hippopus	130.0	50.0	2
Conus spp.	50.0		5
Holothuria edulis	120.0		4
Tripneustes gratilla	75.0		4
Lambis chiragra	160.0		3
Pleuroploca filamentosa	120.0		2
Pleuroploca spp.	72.0		2
Stichopus hermanni	400.0		1
Cassis cornuta	200.0		1
Actinopyga lecanora	130.0		1
Lambis crocata	90.0		1
Pinctada spp.	70.0		1
Conus virgo	70.0		1
Conus bandanus	60.0		1

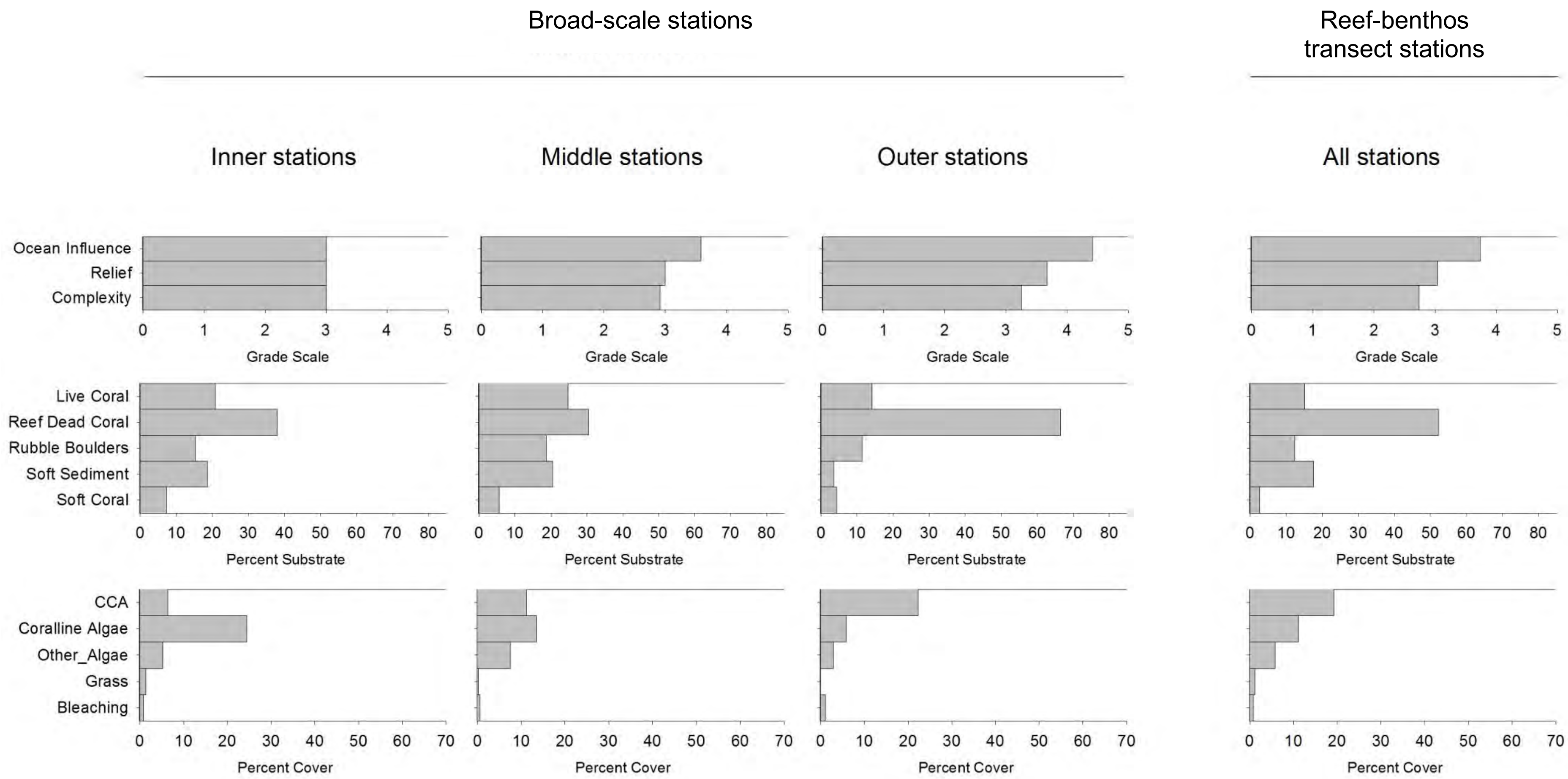
SE = Standard error; n = number.

4.1.8 Nggela species size review – all survey methods (continued)

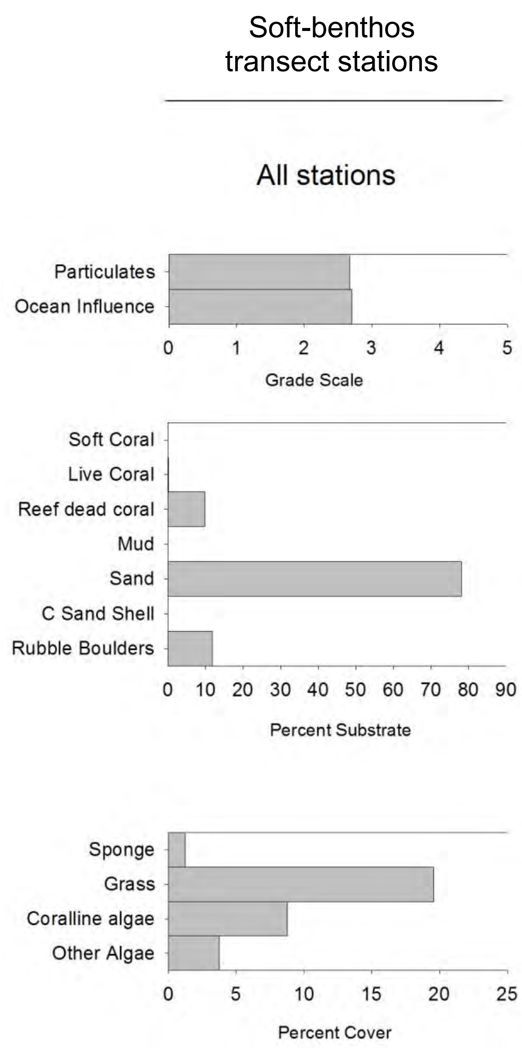
Species	Mean length (cm)	SE	n
Conus generalis	59.0		1
Conus ebraeus	33.0		1
Diadema spp.			1486
Echinothrix diadema			1369
Echinometra mathaei			806
Linckia laevigata			771
Acanthaster planci			341
Beguina semiorbiculata			156
Stichodactyla spp.			146
Culcita novaeguineae			45
Thais spp.			40
Drupella spp.			31
Linckia guildingi			18
Panulirus versicolor			17
Conus miles			16
Choriaster granulatus			15
Synapta spp.			11
Protoreaster nodosus			11
Thalassina spp.			10
Strombus luhuanus			9
Pteria spp.			8
Hyotissa spp.			7
Lambis scorpius			6
Turbo petholatus			6
Holothuria coluber			6
Heterocentrotus mammillatus			5
Atrina vexillum			5
Pinna spp.			4
Heteractis spp.			4
Chama spp.			4
Stichopus horrens			3
Turbo spp.			3
Astralium spp.			3
Oliva spp.			3
Echinothrix calamaris			3
Pleuroploca trapezium			3
Entacmaea quadricolor			3
Cypraea erosa			2
linckia spp.			2
Stichodactyla gigantea			2
Portunus spp.			2
Culcita spp.			2
Cymatium lotorium			1
Nardoa spp.			1
Cypraea moneta			1
Chicoreus brunneus			1
Lysiosquillina maculata			1
Conus pulicarius			1
Turbo argyrostomus			1

SE = Standard error; n = number.

4.1.9 Habitat descriptors for independent assessment – Nggela



4.1.9 Habitat descriptors for independent assessment – Nggela (continued)



4.2 Marau invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Marau

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga echinites*			+	
Bêche-de-mer	*Actinopyga lecanora*		+		+
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+	+	+	+
Bêche-de-mer	*Bohadschia graeffei*	+	+	+	+
Bêche-de-mer	*Bohadschia similis*			+	
Bêche-de-mer	*Bohadschia vitiensis*			+	+
Bêche-de-mer	*Holothuria atra*	+	+	+	+
Bêche-de-mer	*Holothuria edulis*	+			+
Bêche-de-mer	*Holothuria fuscogilva*	+	+	+	+
Bêche-de-mer	*Holothuria fuscopunctata*		+		+
Bêche-de-mer	*Holothuria nobilis*	+	+	+	+
Bêche-de-mer	*Stichopus hermanni*				+
Bêche-de-mer	*Stichopus horrens*		+		+
Bêche-de-mer	*Synapta* spp.		+	+	
Bêche-de-mer	*Thelenota ananas*	+			+
Bivalve	*Anadara scapha*			+	
Bivalve	*Anadara* spp.	+			
Bivalve	*Arca* spp.		+		
Bivalve	*Arca ventricosa*		+		
Bivalve	*Atrina vexillum*			+	
Bivalve	*Beguina semiorbiculata*	+	+		
Bivalve	*Chama* spp.	+		+	+
Bivalve	*Codakia* spp.	+			
Bivalve	*Hippopus hippopus*	+	+	+	+
Bivalve	*Malleus* spp.			+	
Bivalve	*Periglypta* spp.			+	
Bivalve	*Pinctada margaritifera*	+	+	+	+
Bivalve	*Pinna* spp.		+	+	
Bivalve	*Spondylus* spp.		+	+	
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna derasa*	+			
Bivalve	*Tridacna gigas*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna* spp.		+		
Bivalve	*Tridacna squamosa*	+	+	+	+
Cnidarian	*Stichodactyla* spp.	+	+	+	+
Crustacean	*Atergatis floridus*		+		
Crustacean	*Eriphia sebana*				+
Crustacean	*Lysiosquillina maculata*		+	+	
Crustacean	*Odontodactylus scyllarus*		+		
Crustacean	*Panulirus versicolor*	+	+	+	+
Crustacean	*Portunus pelagicus*			+	
Crustacean	*Stenopus hispidus*			+	
Crustacean	*Thor amboinensis*			+	
Gastropod	*Astralium* spp.				+

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Marau (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Bursa cruentata*		+		
Gastropod	*Cassis cornuta*	+			
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Charonia tritonis*	+			
Gastropod	*Chicoreus brunneus*		+	+	
Gastropod	*Chicoreus* spp.		+		+
Gastropod	*Conus bandanus*		+		
Gastropod	*Conus chaldeus*		+		
Gastropod	*Conus coronatus*		+		
Gastropod	*Conus distans*	+	+		+
Gastropod	*Conus episcopatus*		+		
Gastropod	*Conus imperialis*		+	+	
Gastropod	*Conus litteratus*	+	+	+	+
Gastropod	*Conus marmoreus*		+		
Gastropod	*Conus miles*		+		+
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Conus textile*		+		
Gastropod	*Conus vexillum*		+		+
Gastropod	*Conus virgo*		+	+	
Gastropod	*Coralliophila* spp.		+		
Gastropod	*Cypraea annulus*		+	+	
Gastropod	*Cypraea caputserpensis*		+		+
Gastropod	*Cypraea carneola*		+		
Gastropod	*Cypraea erosa*		+		
Gastropod	*Cypraea moneta*		+	+	
Gastropod	*Cypraea* spp.		+		+
Gastropod	*Cypraea tigris*	+	+		+
Gastropod	*Drupa rubusidaeus*		+		
Gastropod	*Haliotis* spp.		+		
Gastropod	*Lambis chiragra*	+	+	+	+
Gastropod	*Lambis lambis*		+	+	
Gastropod	*Lambis millepeda*	+			
Gastropod	*Lambis* spp.	+	+		
Gastropod	*Lambis truncata*	+			
Gastropod	*Latirolagena smaragdula*	+	+		+
Gastropod	*Mitra mitra*			+	
Gastropod	*Nassarius* spp.		+		
Gastropod	*Ovula ovum*	+	+		
Gastropod	*Pleuroploca filamentosa*	+	+		
Gastropod	*Pleuroploca trapezium*		+	+	
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus lentiginosus*		+		
Gastropod	*Strombus luhuanus*		+	+	+
Gastropod	*Strombus* spp.	+	+		
Gastropod	*Tectus fenestratus*		+	+	
Gastropod	*Tectus pyramis*	+	+	+	+
Gastropod	*Thais aculeata*		+		
Gastropod	*Thais* spp.		+	+	+

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Marau (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Trochus maculata*	+	+		+
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Trochus* spp.	+			
Gastropod	*Turbo argyrostomus*		+		+
Gastropod	*Turbo chrysostomus*	+	+		+
Gastropod	*Turbo crassus*				+
Gastropod	*Turbo petholatus*		+		+
Gastropod	*Turbo* spp.		+	+	
Gastropod	*Tutufa rubeta*	+	+		
Gastropod	*Vasum ceramicum*	+	+		+
Gastropod	*Vasum* spp.	+	+		
Octopus	*Octopus cyanea*		+		
Star	*Acanthaster planci*	+	+	+	+
Star	*Choriaster granulatus*				+
Star	*Culcita novaeguineae*	+	+		+
Star	*Linckia laevigata*	+	+		+
Star	*Nardoa* spp.	+			
Star	*Protoreaster nodosus*	+	+	+	+
Urchin	*Diadema* spp.	+	+	+	
Urchin	*Echinometra mathaei*	+	+	+	+
Urchin	*Echinothrix calamaris*	+	+	+	
Urchin	*Echinothrix diadema*	+	+	+	+
Urchin	*Echinothrix* spp.	+			
Urchin	*Heterocentrotus mammillatus*	+			
Urchin	*Toxopneustes pileolus*			+	
Urchin	*Tripneustes gratilla*	+	+	+	+

+ = presence of the species.

4.2.2 Marau broad-scale assessment data review
Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	3.5	2.4	72	50.0	29.3	5	3.5	3.2	12	20.7	18.0	2
Anadara spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Beguina semiorbiculata	11.6	7.4	72	138.9	75.6	6	11.4	8.0	12	68.5	18.5	2
Bohadschia argus	3.0	1.1	72	24.1	4.0	9	3.0	1.4	12	7.2	2.2	5
Bohadschia graeffei	1.6	0.7	72	23.3	4.1	5	1.6	1.0	12	6.5	2.5	3
Cassis cornuta	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Chama spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Charonia tritonis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Codakia spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Conus distans	3.7	1.4	72	29.6	7.2	9	3.7	1.7	12	11.1	2.2	4
Conus litteratus	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Conus spp.	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Culcita novaeguineae	6.5	1.8	72	31.0	4.6	15	6.5	2.2	12	9.7	2.7	8
Cypraea tigris	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Diadema spp.	0.5	0.5	72	33.3		1	0.5	0.5	12	5.5		1
Echinometra mathaei	46.9	19.9	72	120.5	48.6	28	46.8	20.0	12	56.2	23.0	10
Echinothrix calamaris	1.9	0.7	72	19.0	2.4	7	1.8	0.8	12	5.5	0.0	4
Echinothrix diadema	124.2	38.4	72	331.2	90.2	27	124.2	67.7	12	186.3	95.7	8
Echinothrix spp.	2.3	2.1	72	82.1	65.4	2	2.3	2.3	12	27.6		1
Heterocentrotus mammillatus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Hippopus hippopus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Holothuria atra	6.2	1.5	72	27.9	2.9	16	6.2	2.2	12	9.3	2.7	8
Holothuria edulis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Holothuria fuscogilva	1.4	0.6	72	20.0	3.3	5	1.4	0.7	12	4.1	1.4	4
Holothuria nobilis	0.7	0.4	72	16.7	0.0	3	0.7	0.5	12	4.2	1.4	2
Lambis chiragra	1.1	0.8	72	27.5	10.8	3	1.2	0.7	12	4.6	1.8	3
Lambis millepeda	0.4	0.4	72	31.7		1	0.5	0.5	12	5.4		1
Lambis spp.	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.7	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.2 Marau broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Lambis truncata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Latirolagena smaragdula	2.1	1.2	72	29.9	13.3	5	2.1	1.4	12	8.3	4.2	3
Linckia laevigata	69.1	10.5	72	95.6	12.8	52	69.1	14.4	12	69.1	14.4	12
Nardoa spp.	1.1	0.7	72	26.5	5.0	3	1.1	0.9	12	6.8	4.0	2
Ovula ovum	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Panulirus versicolor	1.6	0.7	72	19.4	2.8	6	1.6	0.6	12	3.9	0.7	5
Pinctada margaritifera	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Pleuroploca filamentosa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Protoreaster nodosus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichodactyla spp.	33.1	5.8	72	66.3	8.6	36	33.5	9.1	12	44.6	9.5	9
Strombus spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Tectus pyramis	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Thelenota ananas	0.7	0.4	72	16.0	0.7	3	0.7	0.5	12	4.1	1.3	2
Tridacna crocea	3.7	1.1	72	24.1	2.7	11	3.7	1.6	12	8.8	2.4	5
Tridacna derasa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna gigas	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna maxima	8.5	1.5	72	22.8	2.2	27	8.5	2.2	12	11.4	2.2	9
Tridacna squamosa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		1
Tripneustes gratilla	1.6	1.0	72	29.2	12.5	4	1.6	1.4	12	9.7	6.9	2
Trochus maculata	1.9	1.2	72	33.3	16.7	4	1.8	1.1	12	5.5	2.7	4
Trochus niloticus	3.5	1.6	72	31.2	10.7	8	3.4	1.7	12	8.2	3.1	5
Trochus spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Turbo chrysostomus	0.7	0.5	72	25.0	8.3	2	0.7	0.5	12	4.1	1.3	2
Tutufa rubeta	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Vasum ceramicum	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Vasum spp.	2.5	1.2	72	36.3	8.0	5	2.5	1.7	12	10.2	4.9	3

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.3 Marau reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	31.3	13.0	72	375.0	55.9	6	31.3	21.2	12	187.5	20.8	2
Actinopyga lecanora	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Arca spp.	100.7	54.8	72	1208.3	493.4	6	100.7	100.7	12	1208.3		1
Arca ventricosa	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Atergatis floridus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Beguina semiorbiculata	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Bohadschia argus	20.8	9.6	72	300.0	50.0	5	20.8	9.6	12	62.5	12.0	4
Bohadschia graeffei	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Bursa cruentata	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Cerithium nodulosum	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Chicoreus brunneus	10.4	7.7	72	375.0	125.0	2	10.4	10.4	12	125.0		1
Chicoreus spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus bandanus	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Conus chaldeus	10.4	7.7	72	375.0	125.0	2	10.4	10.4	12	125.0		1
Conus coronatus	17.4	12.4	72	625.0	125.0	2	17.4	17.4	12	208.3		1
Conus distans	76.4	23.5	72	458.3	74.3	12	76.4	39.0	12	183.3	71.7	5
Conus episcopatus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus imperialis	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Conus litteratus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus marmoreus	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Conus miles	125.0	36.3	72	600.0	108.6	15	125.0	68.8	12	214.3	108.1	7
Conus spp.	48.6	16.1	72	350.0	55.3	10	48.6	19.8	12	97.2	27.8	6
Conus textile	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus vexillum	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus virgo	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Coralliophila spp.	31.3	27.9	72	1125.0	875.0	2	31.3	31.3	12	375.0		1
Culcita novaeguineae	17.4	7.5	72	250.0	0.0	5	17.4	6.2	12	41.7	0.0	5
Cypraea annulus	13.9	8.4	72	333.3	83.3	3	13.9	7.8	12	55.6	13.9	3

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.3 Marau reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Cypraea caputserpensis	10.4	5.9	72	250.0	0.0	3	10.4	10.4	12	125.0		1
Cypraea carneola	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Cypraea erosa	10.4	7.7	72	375.0	125.0	2	10.4	10.4	12	125.0		1
Cypraea moneta	20.8	9.6	72	300.0	50.0	5	20.8	10.9	12	62.5	20.8	4
Cypraea tigris	24.3	11.2	72	350.0	61.2	5	24.3	17.4	12	97.2	55.6	3
Diadema spp.	52.1	20.4	72	468.8	99.5	8	52.1	31.3	12	208.3	72.2	3
Drupa rubusidaeus	10.4	7.7	72	375.0	125.0	2	10.4	7.5	12	62.5	20.8	2
Echinometra mathaei	2788.2	515.6	72	4182.3	691.7	48	2788.2	941.3	12	3041.7	993.1	11
Echinothrix calamaris	27.8	10.6	72	285.7	35.7	7	27.8	9.4	12	55.6	8.8	6
Echinothrix diadema	441.0	144.4	72	1380.4	389.4	23	441.0	326.3	12	661.5	479.7	8
Haliotis spp.	20.8	8.2	72	250.0	0.0	6	20.8	14.0	12	83.3	41.7	3
Hippopus hippopus	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Holothuria atra	48.6	29.9	72	700.0	339.1	5	48.6	37.6	12	145.8	104.2	4
Holothuria fuscogilva	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Holothuria fuscopunctata	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Holothuria nobilis	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Lambis chiragra	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Lambis lambis	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Lambis spp.	13.9	6.8	72	250.0	0.0	4	13.9	13.9	12	166.7		1
Latirolagena smaragdula	52.1	30.1	72	625.0	286.9	6	52.1	41.4	12	208.3	146.3	3
Linckia laevigata	284.7	34.0	72	455.6	34.9	45	284.7	60.0	12	310.6	59.3	11
Lysiosquillina maculata	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Nassarius spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Octopus cyanea	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Odontodactylus scyllarus	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Ovula ovum	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Panulirus versicolor	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinctada margaritifera	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.3 Marau reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Pinna spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pleuroploca filamentosa	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Pleuroploca trapezium	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Protoreaster nodosus	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Spondylus spp.	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Stichodactyla spp.	45.1	14.3	72	295.5	45.5	11	45.1	15.8	12	90.3	16.7	6
Stichopus horrens	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Strombus lentiginosus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Strombus luhuanus	27.8	11.7	72	333.3	52.7	6	27.8	12.9	12	83.3	17.0	4
Strombus spp.	319.4	140.9	72	3285.7	890.5	7	319.4	315.7	12	1916.7	1875.0	2
Synapta spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tectus fenestratus	38.2	12.8	72	305.6	36.7	9	38.2	14.9	12	91.7	15.6	5
Tectus pyramis	222.2	29.5	72	390.2	32.7	41	222.2	33.0	12	242.4	28.5	11
Thais aculeata	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Thais spp.	93.8	29.8	72	562.5	102.6	12	93.8	61.6	12	225.0	132.8	5
Tridacna crocea	34.7	11.4	72	277.8	27.8	9	34.7	18.4	12	104.2	36.1	4
Tridacna maxima	142.4	29.6	72	394.2	54.0	26	142.4	52.7	12	189.8	62.9	9
Tridacna spp.	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Tridacna squamosa	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tripneustes gratilla	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Trochus maculata	159.7	38.4	72	479.2	83.7	24	159.7	48.3	12	191.7	52.4	10
Trochus niloticus	20.8	8.2	72	250.0	0.0	6	20.8	8.1	12	50.0	8.3	5
Turbo argyrostomus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Turbo chrysostomus	211.8	41.0	72	564.8	67.5	27	211.8	75.1	12	254.2	84.1	10
Turbo petholatus	13.9	6.8	72	250.0	0.0	4	13.9	5.9	12	41.7	0.0	4
Turbo spp.	20.8	10.8	72	375.0	72.2	4	20.8	15.0	12	125.0	41.7	2
Tutufa rubeta	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Vasum ceramicum	24.3	13.2	72	437.5	119.7	4	24.3	14.9	12	97.2	36.7	3
Vasum spp.	48.6	17.6	72	350.0	76.4	10	48.6	21.7	12	116.7	33.3	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.4 Marau soft-benthos transects (SBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	13.9	8.4	72	333.3	83.3	3	13.9	13.9	12	166.7		1
Actinopyga echinites	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Anadara scapha	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Atrina vexillum	24.3	11.2	72	350.0	61.2	5	24.3	14.0	12	97.2	27.8	3
Bohadschia argus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Bohadschia graeffei	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia similis	69.4	29.8	72	833.3	153.7	6	69.4	51.1	12	416.7	166.7	2
Bohadschia vitiensis	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Chama spp.	52.1	30.5	72	750.0	326.0	5	52.1	32.9	12	208.3	86.7	3
Chicoreus brunneus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus imperialis	17.4	7.5	72	250.0	0.0	5	17.4	9.5	12	69.4	13.9	3
Conus litteratus	166.7	32.8	72	444.4	55.6	27	166.7	53.8	12	222.2	61.3	9
Conus virgo	31.3	9.8	72	250.0	0.0	9	31.3	11.6	12	62.5	14.2	6
Cypraea annulus	52.1	33.5	72	937.5	449.2	4	52.1	48.4	12	312.5	270.8	2
Cypraea moneta	10.4	10.4	72	750.0		1	10.4	10.4	12	125.0		1
Diadema spp.	100.7	60.9	72	1450.0	677.3	5	100.7	82.3	12	302.1	232.8	4
Echinometra mathaei	107.6	54.8	72	1291.7	453.8	6	107.6	100.2	12	430.6	388.9	3
Echinothrix calamaris	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Echinothrix diadema	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Hippopus hippopus	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Holothuria atra	13.9	6.8	72	250.0	0.0	4	13.9	10.7	12	83.3	41.7	2
Holothuria fuscogilva	17.4	9.0	72	312.5	62.5	4	17.4	12.0	12	104.2	20.8	2
Holothuria nobilis	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Lambis chiragra	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Lambis lambis	13.9	8.4	72	333.3	83.3	3	13.9	7.8	12	55.6	13.9	3
Lysiosquillina maculata	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Malleus spp.	10.4	7.7	72	375.0	125.0	2	10.4	10.4	12	125.0		1
Mitra mitra	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.4 Marau soft-benthos transects (SBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Panulirus versicolor	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Periglypta spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinctada margaritifera	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Pinna spp.	13.9	13.9	72	1000.0		1	13.9	13.9	12	166.7		1
Pleuroploca trapezium	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Portunus pelagicus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Protoreaster nodosus	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Spondylus spp.	13.9	6.8	72	250.0	0.0	4	13.9	5.9	12	41.7	0.0	4
Stenopus hispidus	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Stichodactyla spp.	27.8	10.6	72	285.7	35.7	7	27.8	11.8	12	66.7	16.7	5
Strombus gibberulus gibbosus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Strombus luhuanus	17.4	7.5	72	250.0	0.0	5	17.4	9.5	12	69.4	13.9	3
Synapta spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tectus fenestratus	34.7	15.1	72	416.7	83.3	6	34.7	14.4	12	83.3	18.6	5
Tectus pyramis	59.0	39.1	72	1416.7	583.3	3	59.0	37.1	12	236.1	97.2	3
Thais spp.	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Thor amboinensis	13.9	13.9	72	1000.0		1	13.9	13.9	12	166.7		1
Toxopneustes pileolus	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Tridacna squamosa	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tripneustes gratilla	357.6	77.7	72	830.6	141.7	31	357.6	138.3	12	476.9	167.3	9
Turbo spp.	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.5 Marau reef-front search (RFs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Conus distans	15.7	6.6	24	47.1	14.7	8	15.7	7.5	4	15.7	7.5	4
Conus litteratus	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Conus miles	4.9	3.2	24	39.2	15.7	3	4.9	3.7	4	9.8	5.9	2
Conus spp.	6.9	4.4	24	54.9	20.8	3	6.9	3.3	4	9.2	3.5	3
Conus vexillum	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Culcita novaeguineae	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Echinometra mathaei	27.5	8.0	24	54.9	11.3	12	27.5	15.8	4	36.6	18.2	3
Echinothrix diadema	2.9	1.6	24	23.5	0.0	3	2.9	1.9	4	5.9	2.0	2
Latirolagena smaragdula	10.8	9.0	24	129.4	82.4	2	10.8	10.8	4	43.1		1
Linckia laevigata	6.9	2.6	24	27.5	3.9	6	6.9	4.6	4	13.7	5.9	2
Tectus pyramis	11.8	4.0	24	35.3	6.3	8	11.8	3.6	4	11.8	3.6	4
Thais spp.	7.8	2.3	24	23.5	0.0	8	7.8	4.2	4	10.5	4.7	3
Tridacna crocea	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Tridacna maxima	11.8	3.5	24	31.4	3.9	9	11.8	4.8	4	11.8	4.8	4
Trochus maculata	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Turbo argyrostomus	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Turbo chrysostomus	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Turbo crassus	2.0	1.4	24	23.5	0.0	2	2.0	1.1	4	3.9	0.0	2
Vasum ceramicum	5.9	2.6	24	28.2	4.7	5	5.9	4.7	4	11.8	7.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.6 Marau reef-front search by walking (RFs_w) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	7.1	2.4	24	21.4	3.8	8	7.1	4.1	4	9.5	4.8	3
Conus distans	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Conus spp.	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Cypraea caputserpensis	2.4	2.4	24	57.1		1	2.4	2.4	4	9.5		1
Cypraea spp.	1.8	1.3	24	21.4	7.1	2	1.8	1.8	4	7.1		1
Echinothrix diadema	386.3	141.0	24	441.5	157.9	21	386.3	158.7	4	386.3	158.7	4
Eriphia sebana	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Holothuria atra	69.6	13.3	24	88.0	14.0	19	69.6	31.6	4	69.6	31.6	4
Linckia laevigata	23.8	7.9	24	57.1	13.1	10	23.8	8.1	4	31.7	2.1	3
Thais spp.	10.7	3.5	24	25.7	5.6	10	10.7	3.7	4	10.7	3.7	4
Tridacna crocea	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Tridacna maxima	2.4	1.4	24	19.0	4.8	3	2.4	1.4	4	4.8	0.0	2
Trochus maculata	4.2	2.0	24	20.0	5.7	5	4.2	1.5	4	5.6	0.8	3
Trochus niloticus	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Turbo argyrostomus	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Turbo chrysostomus	2.4	1.1	24	14.3	0.0	4	2.4	2.4	4	9.5		1
Turbo crassus	1.8	1.0	24	14.3	0.0	3	1.8	0.6	4	2.4	0.0	3
Vasum ceramicum	1.2	0.8	24	14.3	0.0	2	1.2	1.2	4	4.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.7 Marau mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Bohadschia argus	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Bohadschia graeffei	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Chicoreus spp.	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Culcita novaeguineae	69.4	25.6	36	312.5	62.5	8	69.4	38.3	6	104.2	49.6	4
Cypraea tigris	13.9	9.7	36	250.0	0.0	2	13.9	13.9	6	83.3		1
Echinometra mathaei	55.6	55.6	36	2000.0		1	55.6	55.6	6	333.3		1
Linckia laevigata	291.7	84.8	36	700.0	150.8	15	291.7	146.7	6	437.5	180.4	4
Pinctada margaritifera	27.8	19.4	36	500.0	0.0	2	27.8	17.6	6	83.3	0.0	2
Stichodactyla spp.	55.6	31.7	36	500.0	176.8	4	55.6	25.6	6	83.3	29.5	4
Tectus pyramis	270.8	59.2	36	513.2	77.6	19	270.8	51.3	6	270.8	51.3	6
Thelenota ananas	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Tridacna crocea	13.9	9.7	36	250.0	0.0	2	13.9	8.8	6	41.7	0.0	2
Tridacna maxima	104.2	25.1	36	288.5	26.0	13	104.2	23.4	6	104.2	23.4	6
Tridacna squamosa	34.7	20.3	36	416.7	83.3	3	34.7	16.7	6	69.4	13.9	3
Tripneustes gratilla	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Trochus niloticus	13.9	9.7	36	250.0	0.0	2	13.9	13.9	6	83.3		1
Turbo chrysostomus	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Vasum ceramicum	13.9	13.9	36	500.0		1	13.9	13.9	6	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.8 Marau sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	62.2	26.9	12	186.7	15.4	4	62.2	62.2	2	124.4		1
Astralium spp.	4.4	4.4	12	53.3	-	1	4.4	4.4	2	8.9		1
Bohadschia argus	22.2	13.9	12	88.9	35.6	3	22.2	13.3	2	22.2	13.3	2
Bohadschia graeffei	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Bohadschia vitiensis	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Chama spp.	17.8	17.8	12	213.3		1	17.8	17.8	2	35.6		1
Culcita novaeguineae	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Echinometra mathaei	111.1	89.6	12	666.7	400.0	2	111.1	111.1	2	222.2		1
Echinothrix diadema	44.4	39.8	12	266.7	213.3	2	44.4	35.6	2	44.4	35.6	2
Eriphia sebana	22.2	22.2	12	266.7		1	22.2	22.2	2	44.4		1
Hippopus hippopus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Holothuria atra	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Holothuria edulis	17.8	12.0	12	106.7	0.0	2	17.8	17.8	2	35.6		1
Holothuria fuscogilva	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Holothuria nobilis	13.3	7.0	12	53.3	0.0	3	13.3	4.4	2	13.3	4.4	2
Lambis chiragra	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Linckia laevigata	120.0	37.2	12	180.0	41.5	8	120.0	22.2	2	120.0	22.2	2
Panulirus versicolor	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Pinctada margaritifera	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Protoreaster nodosus	22.2	10.3	12	66.7	13.3	4	22.2	13.3	2	22.2	13.3	2
Stichodactyla spp.	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Stichopus hermanni	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Stichopus horrens	17.8	7.6	12	53.3	0.0	4	17.8	17.8	2	35.6		1
Strombus luhuanus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Tectus pyramis	93.3	36.6	12	160.0	49.4	7	93.3	84.4	2	93.3	84.4	2
Tridacna maxima	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Tripneustes gratilla	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Trochus maculata	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.8 Marau sea cucumber night search (Ns) assessment data review (continued)
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Turbo petholatus	31.1	17.9	12	93.3	40.0	4	31.1	31.1	2	62.2		1
Vasum ceramicum	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.9 Marau sea cucumber day search (Ds) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia argus	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Bohadschia graeffei	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Choriaster granulatus	1.4	1.0	30	21.4	0.0	2	1.4	0.9	5	3.6	0.0	2
Culcita novaeguineae	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Holothuria edulis	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Holothuria fuscogilva	10.7	3.0	30	29.2	4.4	11	10.7	4.8	5	17.8	3.6	3
Holothuria fuscopunctata	2.9	2.2	30	42.8	21.4	2	2.9	2.1	5	7.1	3.6	2
Holothuria nobilis	1.4	1.4	30	42.8		1	1.4	1.4	5	7.1		1
Tridacna squamosa	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.10 Marau species size review – all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	24.3	1.2	164
Tectus pyramis	4.7	0.1	155
Tripneustes gratilla	7.4	0.3	113
Tridacna maxima	13.4	0.6	111
Turbo chrysostomus	3.3	0.4	70
Trochus maculata	3.5	0.3	63
Conus distans	6.7	0.2	55
Conus litteratus	6.7	0.2	53
Tridacna crocea	9.8	0.6	30
Holothuria fuscogilva	28.3	1.7	29
Bohadschia argus	25.7	1.6	28
Conus spp.	5.3	0.4	24
Trochus niloticus	7.1	0.4	24
Bohadschia similis	18.6	0.8	20
Vasum ceramicum	8.8	0.5	20
Bohadschia graeffei	20.9	2.1	14
Actinopyga mauritiana	17.6	1.5	12
Conus virgo	6.9	0.3	12
Pinctada margaritifera	13.1	1.5	12
Cypraea tigris	7.3	0.4	12
Holothuria nobilis	22.1	1.7	11
Lambis chiragra	11.0	0.6	10
Tridacna squamosa	23.8	3.1	9
Conus imperialis	7.0	0.6	8
Hippopus hippopus	15.4	1.5	7
Atrina vexillum	14.0	0.0	7
Holothuria edulis	28.7	2.5	6
Lambis spp.	10.8	0.5	6
Spondylus spp.	10.0	3.0	6
Bohadschia vitiensis	17.8	1.7	5
Holothuria fuscopunctata	35.4	4.4	5
Stichopus horrens	27.6	4.6	5
Pleuroploca trapezium	11.1	1.7	5
Thelenota ananas	33.8	9.0	4
Conus marmoreus	4.5	0.3	4
Tutufa rubeta	6.9	1.3	4
Cassis cornuta	27.0	3.0	3
Anadara scapha	6.0	0.5	2
Tridacna spp.	4.8	3.3	2
Cerithium nodulosum	9.6	0.1	2
Conus bandanus	6.0	0.0	2
Conus textile	5.9	0.6	2
Strombus spp.	4.5		93
Thais spp.	5.0		56
Conus miles	4.5		41
Tectus fenestratus	2.7		21
Strombus luhuanus	4.0		14
Turbo crassus	5.5		5

SE = Standard error; n = number.

4.2.10 Marau species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Actinopyga lecanora	24.0		2
Conus vexillum	5.6		2
Actinopyga echinites	15.0		1
Stichopus hermanni	48.0		1
Anadara spp.	5.0		1
Codakia spp.	4.0		1
Periglypta spp.	6.0		1
Tridacna derasa	22.0		1
Tridacna gigas	16.0		1
Conus episcopatus	5.5		1
Mitra mitra	5.6		1
Pleuroploca filamentosa	8.0		1
Echinothrix diadema			1327
Echinometra mathaei			1098
Linckia laevigata			499
Stichodactyla spp.			177
Beguina semiorbiculata			53
Culcita novaeguineae			46
Diadema spp.			46
Acanthaster planci			42
Latirolagena smaragdula			35
Arca spp.			29
Vasum spp.			25
Chama spp.			20
Cypraea annulus			19
Echinothrix calamaris			17
Protoreaster nodosus			12
Turbo petholatus			11
Panulirus versicolor			10
Echinothrix spp.			10
Coralliophila spp.			9
Cypraea moneta			9
Lambis lambis			8
Turbo spp.			8
Cypraea caputserpensis			7
Eriphia sebana			6
Haliotis spp.			6
Pinna spp.			5
Conus coronatus			5
Nardoa spp.			5
Thor amboinensis			4
Chicoreus brunneus			4
Malleus spp.			3
Conus chaldeus			3
Cypraea erosa			3
Cypraea spp.			3
Drupa rubusidaeus			3
Thais aculeata			3

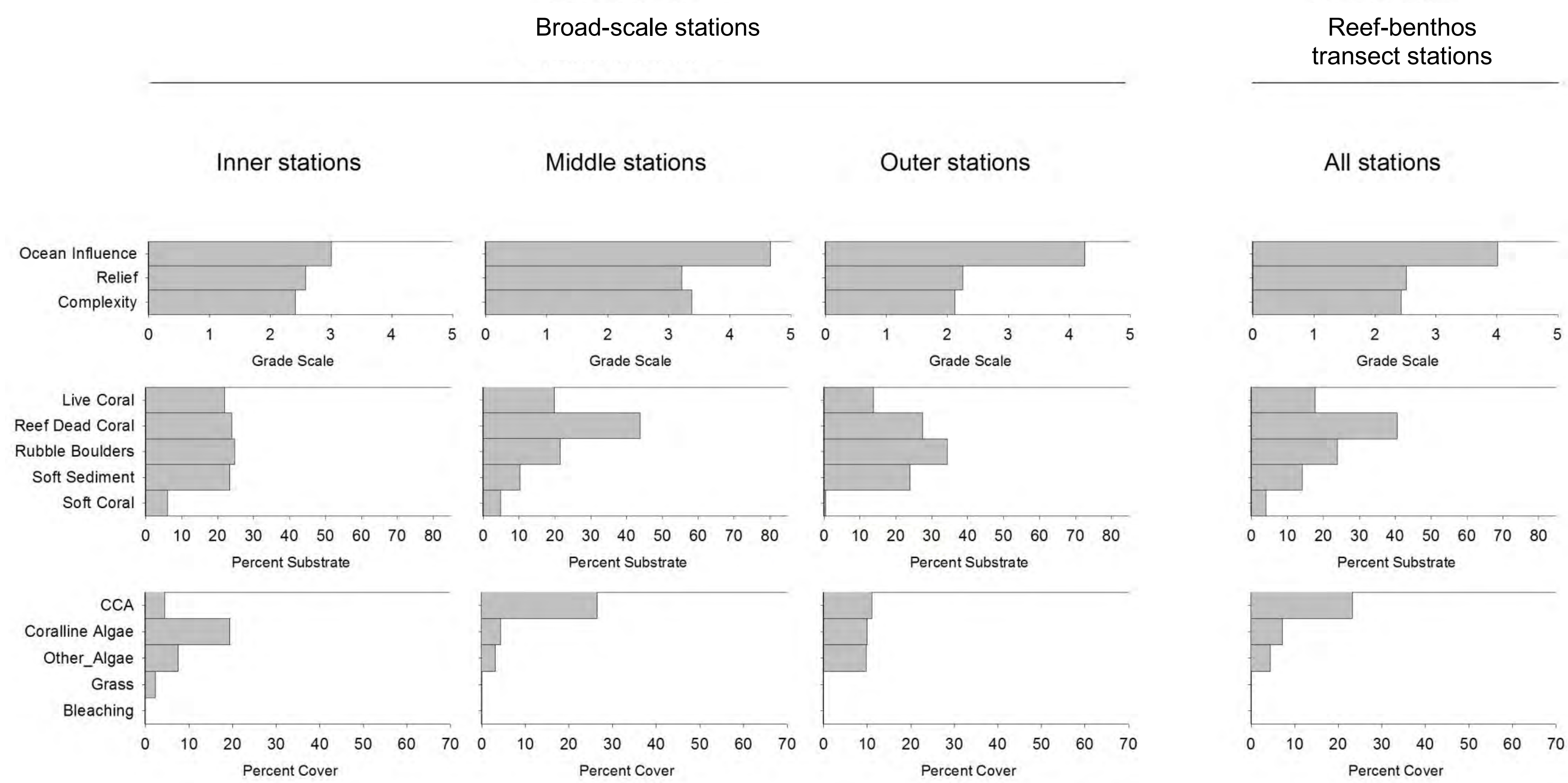
SE = Standard error; n = number.

4.2.10 Marau species size review – all survey methods (continued)

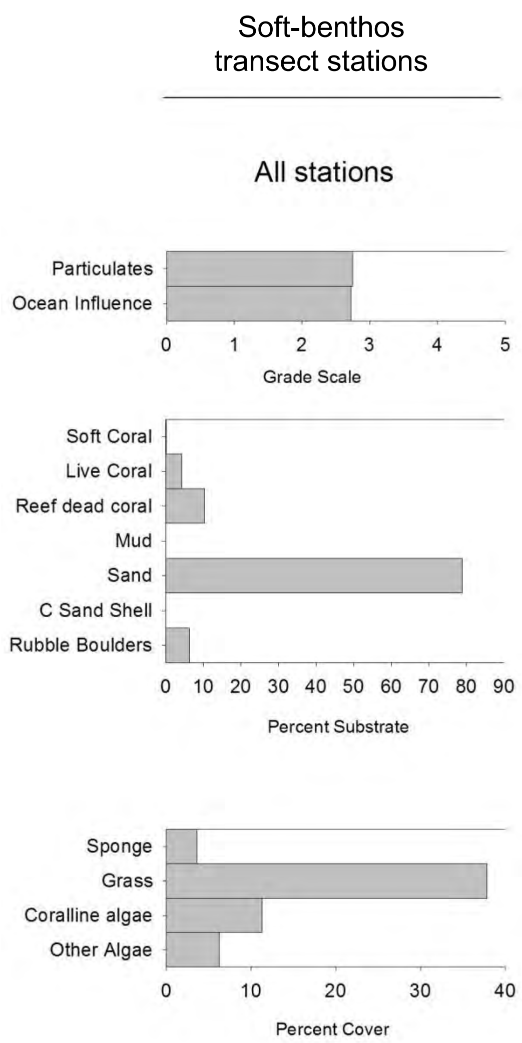
Species	Mean length (cm)	SE	n
Turbo argyrostomus			3
Toxopneustes pileolus			3
Synapta spp.			2
Lysiosquillina maculata			2
Odontodactylus scyllarus			2
Stenopus hispidus			2
Chicoreus spp.			2
Lambis millepeda			2
Ovula ovum			2
Choriaster granulatus			2
Arca ventricosa			1
Atergatis floridus			1
Portunus pelagicus			1
Astralium spp.			1
Bursa cruentata			1
Charonia tritonis			1
Cypraea carneola			1
Lambis truncata			1
Nassarius spp.			1
Strombus gibberulus gibbosus			1
Strombus lentiginosus			1
Trochus spp.			1
Octopus cyanea			1
Heterocentrotus mammillatus			1

SE = Standard error; n = number.

4.2.11 Habitat descriptors for independent assessments – Marau



4.2.11 Habitat descriptors for independent assessments – Marau (continued)



4.3 Rarumana invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Rarumana

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*		+		+
Bêche-de-mer	*Actinopyga miliaris*				+
Bêche-de-mer	*Bohadschia argus*		+		+
Bêche-de-mer	*Bohadschia graeffei*	+			+
Bêche-de-mer	*Bohadschia vitiensis*	+	+	+	+
Bêche-de-mer	*Holothuria atra*	+	+	+	+
Bêche-de-mer	*Holothuria coluber*				+
Bêche-de-mer	*Holothuria edulis*	+			+
Bêche-de-mer	*Holothuria fuscogilva*	+			+
Bêche-de-mer	*Holothuria fuscopunctata*				+
Bêche-de-mer	*Stichopus hermanni*	+			
Bêche-de-mer	*Stichopus vastus*	+			
Bêche-de-mer	*Thelenota ananas*		+		
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Anadara scapha*			+	
Bivalve	*Anadara* spp.		+	+	
Bivalve	*Atrina vexillum*	+	+	+	
Bivalve	*Beguina semiorbiculata*	+	+		+
Bivalve	*Chama* spp.		+		
Bivalve	*Hippopus hippopus*		+		
Bivalve	*Hyotissa* spp.	+	+		+
Bivalve	*Periglypta puerpera*			+	
Bivalve	*Pinctada margaritifera*	+	+	+	+
Bivalve	*Pteria* spp.		+		+
Bivalve	*Spondylus* spp.	+	+	+	+
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna derasa*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna* spp.	+			
Bivalve	*Tridacna squamosa*	+	+		+
Cnidarian	*Cassiopea* spp.		+	+	
Cnidarian	*Entacmaea quadricolor*	+	+		+
Cnidarian	*Stichodactyla* spp.	+	+	+	+
Crustacean	*Atergatis floridus*				+
Crustacean	*Etisus splendidus*				+
Crustacean	*Lysiosquillina maculata*	+			+
Crustacean	*Panulirus versicolor*	+	+		+
Crustacean	*Saron* spp.		+		
Crustacean	*Stenopus hispidus*		+		
Crustacean	*Thor amboinensis*		+		
Gastropod	*Astralium* spp.		+		
Gastropod	*Cerithium aluco*		+		
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Cerithium* spp.			+	
Gastropod	*Conus capitaneus*		+		
Gastropod	*Conus distans*		+		+

+ = presence of the species.

4.3.1 Invertebrate species recorded in different assessments in Rarumana (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Conus eburneus*			+	
Gastropod	*Conus flavidus*		+		
Gastropod	*Conus imperialis*		+		
Gastropod	*Conus leopardus*	+	+	+	
Gastropod	*Conus litteratus*	+	+		+
Gastropod	*Conus lividus*		+	+	
Gastropod	*Conus marmoreus*	+			+
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.		+	+	+
Gastropod	*Conus textile*		+		
Gastropod	*Conus virgo*	+	+	+	+
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea carneola*		+		
Gastropod	*Cypraea moneta*		+		
Gastropod	*Cypraea* spp.		+		
Gastropod	*Cypraea tigris*	+	+	+	+
Gastropod	*Drupa rubusidaeus*		+		
Gastropod	*Drupa* spp.		+		
Gastropod	*Lambis chiragra*				+
Gastropod	*Lambis lambis*	+	+	+	
Gastropod	*Lambis millepeda*	+	+		+
Gastropod	*Lambis scorpius*	+			+
Gastropod	*Lambis* spp.		+		
Gastropod	*Latirolagena smaragdula*		+		+
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus luhuanus*	+	+	+	
Gastropod	*Tectus pyramis*		+		+
Gastropod	*Thais* spp.	+	+		+
Gastropod	*Trochus maculata*		+		
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Turbo argyrostomus*		+		+
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Turbo petholatus*		+		
Gastropod	*Turbo setosus*				+
Gastropod	*Turbo* spp.		+		
Gastropod	*Tutufa rubeta*		+		
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum* spp.		+		
Star	*Acanthaster planci*	+	+		+
Star	*Choriaster granulatus*	+	+		+
Star	*Culcita novaeguineae*	+	+	+	+
Star	*Fromia* spp.	+	+		+
Star	*Linckia guildingi*		+		+
Star	*Linckia laevigata*	+	+	+	+
Urchin	*Diadema* spp.	+	+	+	+
Urchin	*Echinometra mathaei*		+	+	+
Urchin	*Echinothrix calamaris*	+	+		+
Urchin	*Echinothrix diadema*	+	+		+

+ = presence of the species.

4.3.1 Invertebrate species recorded in different assessments in Rarumana (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Urchin	*Heterocentrotus mammillatus*		+		+
Urchin	*Mespilia globulus*			+	
Urchin	*Tripneustes gratilla*	+	+	+	

+ = presence of the species.

4.3.2 Rarumana broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Atrina vexillum	1.4	0.5	72	16.7	0.0	6	1.4	0.5	12	3.3	0.6	5
Beguina semiorbiculata	63.7	35.7	72	509.3	249.5	9	63.6	42.5	12	152.6	92.4	5
Bohadschia graeffei	0.7	0.4	72	16.7	0.0	3	0.7	0.5	12	4.2	1.4	2
Bohadschia vitiensis	1.6	0.6	72	16.7	0.0	7	1.6	0.8	12	4.9	1.3	4
Choriaster granulatus	0.7	0.5	72	25.0	8.3	2	0.7	0.5	12	4.2	1.4	2
Conus leopardus	0.9	0.7	72	33.3	16.7	2	0.9	0.9	12	11.1		1
Conus litteratus	1.9	0.7	72	19.0	2.4	7	1.9	1.2	12	5.6	2.8	4
Conus marmoreus	1.4	0.5	72	16.7	0.0	6	1.4	0.9	12	5.6	2.8	3
Conus virgo	0.5	0.3	72	16.7	0.0	2	0.5	0.5	12	5.6		1
Culcita novaeguineae	3.9	1.1	72	20.2	2.6	14	3.9	1.5	12	9.4	1.4	5
Cypraea tigris	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Diadema spp.	1.6	1.1	72	58.3	8.3	2	1.6	1.6	12	19.4		1
Echinothrix calamaris	1.4	0.9	72	33.3	9.6	3	1.4	1.2	12	8.3	5.6	2
Echinothrix diadema	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Entacmaea quadricolor	3.0	1.2	72	31.0	5.7	7	3.0	1.7	12	12.0	3.3	3
Fromia spp.	0.7	0.5	72	25.0	8.3	2	0.7	0.5	12	4.2	1.4	2
Holothuria atra	5.8	1.7	72	27.7	5.1	15	5.8	2.0	12	7.7	2.4	9
Holothuria edulis	1.4	0.5	72	16.7	0.0	6	1.4	0.9	12	5.5	2.8	3
Holothuria fuscogilva	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Hyotissa spp.	1.4	1.0	72	33.3	16.7	3	1.4	0.9	12	5.6	2.8	3
Lambis lambis	2.1	0.8	72	21.3	3.0	7	2.1	0.8	12	5.0	1.0	5
Lambis millepeda	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Lambis millepeda	0.2	0.2	72	16.7		1	0.0	0.0	12			0
Lambis scorpius	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Linckia laevigata	35.4	8.2	72	82.3	15.6	31	35.4	12.9	12	47.2	15.3	9
Lysiosquillina maculata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Panulirus versicolor	0.9	0.6	72	22.2	5.6	3	0.9	0.5	12	3.7	0.9	3

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.2 Rarumana broad-scale assessment data review (continued)
Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Pinctada margaritifera	4.2	1.4	72	30.0	5.4	10	4.2	1.9	12	8.3	2.9	6
Spondylus spp.	2.1	0.8	72	21.4	3.1	7	2.1	1.4	12	8.3	4.2	3
Stichodactyla spp.	1.4	0.8	72	25.0	8.3	4	1.4	0.9	12	5.6	2.8	3
Stichopus hermanni	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichopus vastus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Strombus luhuanus	4.2	2.1	72	42.9	15.4	7	4.2	2.4	12	12.5	5.4	4
Thais spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	28.7	9.5	72	86.1	25.0	24	28.7	15.4	12	38.3	19.7	9
Tridacna derasa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna maxima	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Tridacna spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna squamosa	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tripneustes gratilla	1.1	0.6	72	20.7	4.2	4	1.2	0.6	12	4.6	0.9	3
Trochus niloticus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Rarumana reef-benthos transect (RBt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	15.6	8.1	96	375.0	72.2	4	15.6	11.3	16	125.0	41.7	2
Actinopyga lecanora	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Anadara spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Astralium spp.	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Atrina vexillum	7.8	4.5	96	250.0	0.0	3	7.8	5.7	16	62.5	20.8	2
Beguina semiorbiculata	78.1	42.1	96	1071.4	455.5	7	78.1	49.9	16	250.0	138.2	5
Bohadschia argus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Rarumana reef-benthos transect (RBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia vitiensis	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cassiopea spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cerithium aluco	15.6	8.9	96	375.0	125.0	4	15.6	8.4	16	62.5	20.8	4
Cerithium nodulosum	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Chama spp.	28.6	23.7	96	916.7	666.7	3	28.6	23.7	16	229.2	145.8	2
Choriaster granulatus	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	2
Conus capitaneus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Conus distans	5.2	3.7	96	250.0	0.0	2	5.2	5.2	16	83.3		1
Conus flavidus	26.0	10.1	96	357.1	50.5	7	26.0	14.2	16	138.9	13.9	3
Conus imperialis	7.8	4.5	96	250.0	0.0	3	7.8	5.7	16	62.5	20.8	2
Conus leopardus	7.8	5.8	96	375.0	125.0	2	7.8	7.8	16	125.0		1
Conus litteratus	10.4	5.1	96	250.0	0.0	4	10.4	6.0	16	55.6	13.9	3
Conus lividus	5.2	5.2	96	500.0		1	5.2	5.2	16	83.3		1
Conus miles	18.2	8.5	96	350.0	61.2	5	18.2	11.4	16	97.2	36.7	3
Conus spp.	10.4	10.4	96	1000.0		1	10.4	10.4	16	166.7		1
Conus textile	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Conus virgo	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Culcita novaeguineae	41.7	11.5	96	307.7	30.4	13	41.7	17.0	16	95.2	28.3	7
Cypraea annulus	23.4	13.9	96	450.0	200.0	5	23.4	18.2	16	125.0	83.3	3
Cypraea carneola	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Cypraea moneta	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cypraea spp.	10.4	6.3	96	333.3	83.3	3	10.4	6.0	16	55.6	13.9	3
Cypraea tigris	31.3	8.5	96	250.0	0.0	12	31.3	8.9	16	62.5	7.9	8
Diadema spp.	182.3	91.0	96	1590.9	680.3	11	182.3	121.8	16	729.2	404.5	4
Drupa rubusidaeus	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	2
Drupa spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Echinometra mathaei	1164.1	209.1	96	2 031.8	318.7	55	1 164.1	353.1	16	1 164.1	353.1	16
Echinothrix calamaris	39.1	11.3	96	312.5	32.6	12	39.1	19.9	16	125.0	45.6	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Rarumana reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Echinothrix diadema	190.1	60.4	96	1140.6	257.2	16	190.1	108.0	16	506.9	247.3	6
Entacmaea quadricolor	7.8	4.5	96	250.0	0.0	3	7.8	4.2	16	41.7	0.0	3
Fromia spp.	26.0	10.1	96	312.5	62.5	8	26.0	11.3	16	69.4	20.6	6
Heterocentrotus mammillatus	5.2	3.7	96	250.0	0.0	2	5.2	5.2	16	83.3		1
Hippopus hippopus	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Holothuria atra	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Hyotissa spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Lambis lambis	26.0	8.7	96	277.8	27.8	9	26.0	9.2	16	59.5	12.4	7
Lambis millepeda	13.0	6.8	96	312.5	62.5	4	13.0	7.3	16	69.4	13.9	3
Lambis spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Latirolagena smaragdula	41.7	19.1	96	571.4	170.0	7	41.7	31.6	16	222.2	141.0	3
Linckia guildingi	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Linckia laevigata	440.1	51.8	96	630.6	60.9	67	440.1	83.7	16	440.1	83.7	16
Panulirus versicolor	7.8	4.5	96	250.0	0.0	3	7.8	4.2	16	41.7	0.0	3
Pinctada margaritifera	72.9	14.8	96	304.3	27.0	23	72.9	16.8	16	89.7	17.6	13
Pteria spp.	23.4	13.4	96	750.0	0.0	3	23.4	12.6	16	125.0	0.0	3
Saron spp.	5.2	5.2	96	500.0		1	5.2	5.2	16	83.3		1
Spondylus spp.	13.0	5.7	96	250.0	0.0	5	13.0	5.0	16	41.7	0.0	5
Stenopus hispidus	5.2	5.2	96	500.0		1	5.2	5.2	16	83.3		1
Stichodactyla spp.	18.2	9.3	96	350.0	100.0	5	18.2	8.5	16	58.3	16.7	5
Strombus luhuanus	41.7	14.2	96	400.0	66.7	10	41.7	16.6	16	111.1	25.6	6
Tectus pyramis	93.8	21.0	96	360.0	52.2	25	93.8	30.8	16	125.0	37.0	12
Thais spp.	23.4	9.1	96	321.4	46.1	7	23.4	10.7	16	62.5	20.8	6
Thelenota ananas	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Thor amboinensis	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Tridacna crocea	96.4	18.3	96	355.8	31.5	26	96.4	26.5	16	128.5	30.1	12
Tridacna maxima	140.6	21.5	96	346.2	31.3	39	140.6	30.9	16	160.7	31.8	14
Tridacna squamosa	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Rarumana reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Tripneustes gratilla	13.0	6.8	96	312.5	62.5	4	13.0	10.6	16	104.2	62.5	2
Trochus maculata	39.1	11.3	96	312.5	32.6	12	39.1	11.7	16	69.4	13.9	9
Trochus niloticus	20.8	10.3	96	400.0	100.0	5	20.8	11.4	16	83.3	29.5	4
Turbo argyrostomus	28.6	11.0	96	343.8	65.8	8	28.6	14.1	16	91.7	30.6	5
Turbo chrysostomus	10.4	5.1	96	250.0	0.0	4	10.4	4.7	16	41.7	0.0	4
Turbo petholatus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Turbo spp.	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	2
Tutufa rubeta	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Vasum ceramicum	5.2	5.2	96	500.0		1	5.2	5.2	16	83.3		1
Vasum spp.	10.4	6.3	96	333.3	83.3	3	10.4	7.1	16	83.3	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.4 Rarumana soft-benthos transects (SBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara scapha	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Atrina vexillum	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Bohadschia vitiensis	10.4	7.7	72	375.0	125.0	2	10.4	10.4	12	125.0		1
Cassiopea spp.	10.4	7.7	72	375.0	125.0	2	10.4	7.5	12	62.5	20.8	2
Conus leopardus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Culcita novaeguineae	24.3	8.8	72	250.0	0.0	7	24.3	9.5	12	58.3	10.2	5
Cypraea tigris	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Diadema spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Echinometra mathaei	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Holothuria atra	20.8	8.2	72	250.0	0.0	6	20.8	9.6	12	62.5	12.0	4
Lambis lambis	20.8	8.2	72	250.0	0.0	6	20.8	8.1	12	50.0	8.3	5
Linckia laevigata	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Mespilia globulus	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Pinctada margaritifera	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Spondylus spp.	13.9	6.8	72	250.0	0.0	4	13.9	5.9	12	41.7	0.0	4
Stichodactyla spp.	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Tripneustes gratilla	13.9	6.8	72	250.0	0.0	4	13.9	10.7	12	83.3	41.7	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.5 Rarumana soft-benthos quadrats (SBq) assessment data review

Station: 8 quadrat groups (4 quadrats/group).

Species	Quadrat groups			Quadrat groups _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara scapha	0.58	0.16	104	4.62	0.42	13	0.58	0.23	13	1.50	0.27	5
Anadara spp.	0.42	0.13	104	4.40	0.40	10	0.42	0.17	13	1.10	0.19	5
Cerithium spp.	0.27	0.16	104	9.33	1.33	3	0.27	0.20	13	1.75	0.75	2
Conus eburneus	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Conus lividus	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Conus spp.	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Conus virgo	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Periglypta puerpera	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Strombus gibberulus gibbosus	0.04	0.04	104	4.00		1	0.04	0.04	13	0.50		1
Strombus luhuanus	1.15	0.31	104	6.67	1.07	18	1.15	0.47	13	2.14	0.69	7

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.6 Rarumana reef-front search (RFs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Beguina semiorbiculata	7.8	4.6	30	58.8	22.5	4	7.8	6.9	5	19.6	15.7	2
Bohadschia argus	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Bohadschia graeffei	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Choriaster granulatus	9.4	4.3	30	40.3	13.3	7	9.4	5.1	5	15.7	6.0	3
Conus distans	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus marmoreus	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus spp.	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus virgo	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Culcita novaeguineae	7.8	3.1	30	33.6	7.0	7	7.8	3.5	5	9.8	3.8	4
Cypraea tigris	3.1	1.5	30	23.5	0.0	4	3.1	1.5	5	5.2	1.3	3
Echinometra mathaei	18.8	7.6	30	62.7	18.8	9	18.8	5.7	5	23.5	4.2	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.6 Rarumana reef-front search (RFs) assessment data review (continued)

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Echinothrix diadema	2.4	1.7	30	35.3	11.8	2	2.4	1.6	5	5.9	2.0	2
Entacmaea quadricolor	12.5	4.9	30	47.1	11.8	8	12.5	7.9	5	15.7	9.3	4
Fromia spp.	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Heterocentrotus mammillatus	5.5	2.2	30	27.5	3.9	6	5.5	1.0	5	5.5	1.0	5
Holothuria atra	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Holothuria edulis	4.7	1.7	30	23.5	0.0	6	4.7	1.5	5	5.9	1.1	4
Hyotissa spp.	3.1	1.9	30	31.4	7.8	3	3.1	1.9	5	7.8	0.0	2
Lambis chiragra	3.9	3.2	30	58.8	35.3	2	3.9	3.0	5	9.8	5.9	2
Lambis millepeda	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Lambis scorpius	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Linckia guildingi	2.4	1.3	30	23.5	0.0	3	2.4	1.6	5	5.9	2.0	2
Linckia laevigata	38.4	10.8	30	82.4	16.9	14	38.4	11.6	5	38.4	11.6	5
Panulirus versicolor	3.1	1.5	30	23.5	0.0	4	3.1	0.8	5	3.9	0.0	4
Pinctada margaritifera	11.8	4.2	30	39.2	8.8	9	11.8	3.0	5	11.8	3.0	5
Spondylus spp.	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Stichodactyla spp.	3.9	2.0	30	29.4	5.9	4	3.9	1.8	5	6.5	1.3	3
Tectus pyramis	14.1	6.7	30	52.9	20.3	8	14.1	11.3	5	23.5	17.7	3
Thais spp.	0.8	0.8	30	23.5	-	1	0.8	0.8	5	3.9		1
Tridacna crocea	15.7	3.4	30	31.4	3.7	15	15.7	4.3	5	15.7	4.3	5
Tridacna maxima	22.0	4.5	30	43.9	3.9	15	22.0	4.7	5	22.0	4.7	5
Tridacna squamosa	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Trochus niloticus	3.1	1.9	30	31.4	7.8	3	3.1	2.3	5	7.8	3.9	2
Vasum ceramicum	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.7 Rarumana mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Conus distans	18.2	9.8	48	218.8	59.8	4	18.2	10.0	8	48.6	13.9	3
Conus spp.	5.2	3.6	48	125.0	0.0	2	5.2	3.4	8	20.8	0.0	2
Culcita novaeguineae	7.8	4.4	48	125.0	0.0	3	7.8	3.8	8	20.8	0.0	3
Holothuria atra	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Holothuria edulis	5.2	3.6	48	125.0	0.0	2	5.2	5.2	8	41.7		1
Holothuria fuscopunctata	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Latirolagena smaragdula	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Linckia laevigata	18.2	12.9	48	437.5	62.5	2	18.2	18.2	8	145.8		1
Lysiosquillina maculata	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Pinctada margaritifera	7.8	4.4	48	125.0	0.0	3	7.8	3.8	8	20.8	0.0	3
Stichodactyla spp.	5.2	5.2	48	250.0		1	5.2	5.2	8	41.7		1
Tectus pyramis	62.5	14.9	48	200.0	20.4	15	62.5	15.2	8	71.4	14.3	7
Tridacna crocea	5.2	3.6	48	125.0	0.0	2	5.2	3.4	8	20.8	0.0	2
Tridacna maxima	67.7	14.4	48	180.6	18.1	18	67.7	22.2	8	67.7	22.2	8
Tridacna squamosa	7.8	4.4	48	125.0	0.0	3	7.8	3.8	8	20.8	0.0	3
Trochus niloticus	10.4	5.0	48	125.0	0.0	4	10.4	5.6	8	27.8	6.9	3
Turbo argyrostomus	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Turbo setosus	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1
Vasum ceramicum	2.6	2.6	48	125.0		1	2.6	2.6	8	20.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.8 Rarumana sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	13.3	9.6	12	80.0	26.7	2.0	13.3	4.4	2	13.3	4.4	2
Actinopyga lecanora	8.9	6.0	12	53.3	0.0	2.0	8.9	0.0	2	8.9	0.0	2
Actinopyga miliaris	17.8	10.0	12	71.1	17.8	3.0	17.8	17.8	2	35.6		1
Atergatis floridus	4.4	4.4	12	53.3		1.0	4.4	4.4	2	8.9		1
Bohadschia vitiensis	22.2	17.9	12	133.3	80.0	2.0	22.2	22.2	2	44.4		1
Culcita novaeguineae	8.9	6.0	12	53.3	0.0	2.0	8.9	8.9	2	17.8		1
Diadema spp.	386.7	206.5	12	1546.7	201.9	3.0	386.7	386.7	2	773.3		1
Echinothrix calamaris	93.3	53.8	12	373.3	106.7	3.0	93.3	93.3	2	186.7		1
Echinothrix diadema	155.6	94.6	12	622.2	227.0	3.0	155.6	155.6	2	311.1		1
Etisus splendidus	13.3	9.6	12	80.0	26.7	2.0	13.3	13.3	2	26.7		1
Holothuria coluber	57.8	20.2	12	115.6	21.4	6.0	57.8	48.9	2	57.8	48.9	2
Holothuria edulis	31.1	19.1	12	124.4	47.0	3.0	31.1	13.3	2	31.1	13.3	2
Linckia laevigata	266.7	92.6	12	355.6	108.5	9.0	266.7	186.7	2	266.7	186.7	2
Panulirus versicolor	17.8	7.6	12	53.3	0.0	4.0	17.8	0.0	2	17.8	0.0	2
Stichodactyla spp.	4.4	4.4	12	53.3		1.0	4.4	4.4	2	8.9		1
Tridacna crocea	17.8	17.8	12	213.3		1.0	17.8	17.8	2	35.6		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.9 Rarumana sea cucumber day search (Ds) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period P			Station			Station P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia graeffei	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Bohadschia vitiensis	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Choriaster granulatus	12.1	5.2	30	52.0	14.7	7.0	12.1	10.4	5	30.3	23.2	2
Conus litteratus	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Culcita novaeguineae	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Holothuria edulis	1.4	1.0	30	21.4	0.0	2.0	1.4	0.9	5	3.6	0.0	2
Holothuria fuscogilva	5.0	2.4	30	30.0	8.6	5.0	5.0	2.7	5	8.3	3.1	3
Holothuria fuscopunctata	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Linckia guildingi	2.1	1.6	30	32.1	10.7	2.0	2.1	2.1	5	10.7		1
Pinctada margaritifera	2.9	2.9	30	85.7		1.0	2.9	2.9	5	14.3		1
Pteria spp.	1.4	1.0	30	21.4	0.0	2.0	1.4	1.4	5	7.1		1
Spondylus spp.	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Thelenota anax	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1
Tridacna squamosa	0.7	0.7	30	21.4		1.0	0.7	0.7	5	3.6		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.10 Rarumana species size review — all survey methods

Species	Mean length (cm)	SE	n
Tridacna crocea	71.4	2.9	187
Tridacna maxima	123.4	5.4	119
Tectus pyramis	55.1	0.9	78
Pinctada margaritifera	109.7	5.1	69
Holothuria atra	196.9	17.6	34
Lambis lambis	120.0	8.2	25
Holothuria edulis	248.3	26.0	23
Cypraea tigris	77.2	2.3	22
Bohadschia vitiensis	250.0	19.2	17
Trochus niloticus	91.5	4.3	17
Trochus maculata	35.0	5.0	15
Conus litteratus	65.7	2.3	13
Atrina vexillum	275.0	25.0	12
Tridacna squamosa	218.9	41.5	9
Holothuria fuscogilva	326.9	35.0	8
Conus leopardus	95.0	5.3	8
Conus spp.	70.0	10.0	8
Bohadschia graeffei	288.0	24.4	6
Conus virgo	80.0	10.0	6
Vasum spp.	70.0	0.0	4
Conus imperialis	70.0	0.0	3
Holothuria fuscopunctata	335.0	105.0	2
Bohadschia argus	205.0	5.0	2
Hippopus hippopus	160.0	50.0	2
Cerithium nodulosum	85.0	5.0	2
Thelenota anax	600		1
Thelenota ananas	450		1
Stichopus vastus	350		1
Stichopus hermanni	300		1
Actinopyga lecanora	150		3
Lambis spp.	130		1
Tripneustes gratilla	80		14
Conus textile	60		1
Anadara spp.	50		11
Anadara scapha	40		13
Conus flavidus	40		10
Turbo chrysostomus	40		4
Astralium spp.	35		2
Echinometra mathaei			473
Linckia laevigata			440
Beguina semiorbiculata			315
Diadema spp.			165
Echinothrix diadema			113
Strombus luhuanus			64
Culcita novaeguineae			56
Echinothrix calamaris			42
Choriaster granulatus			35
Entacmaea quadricolor			32

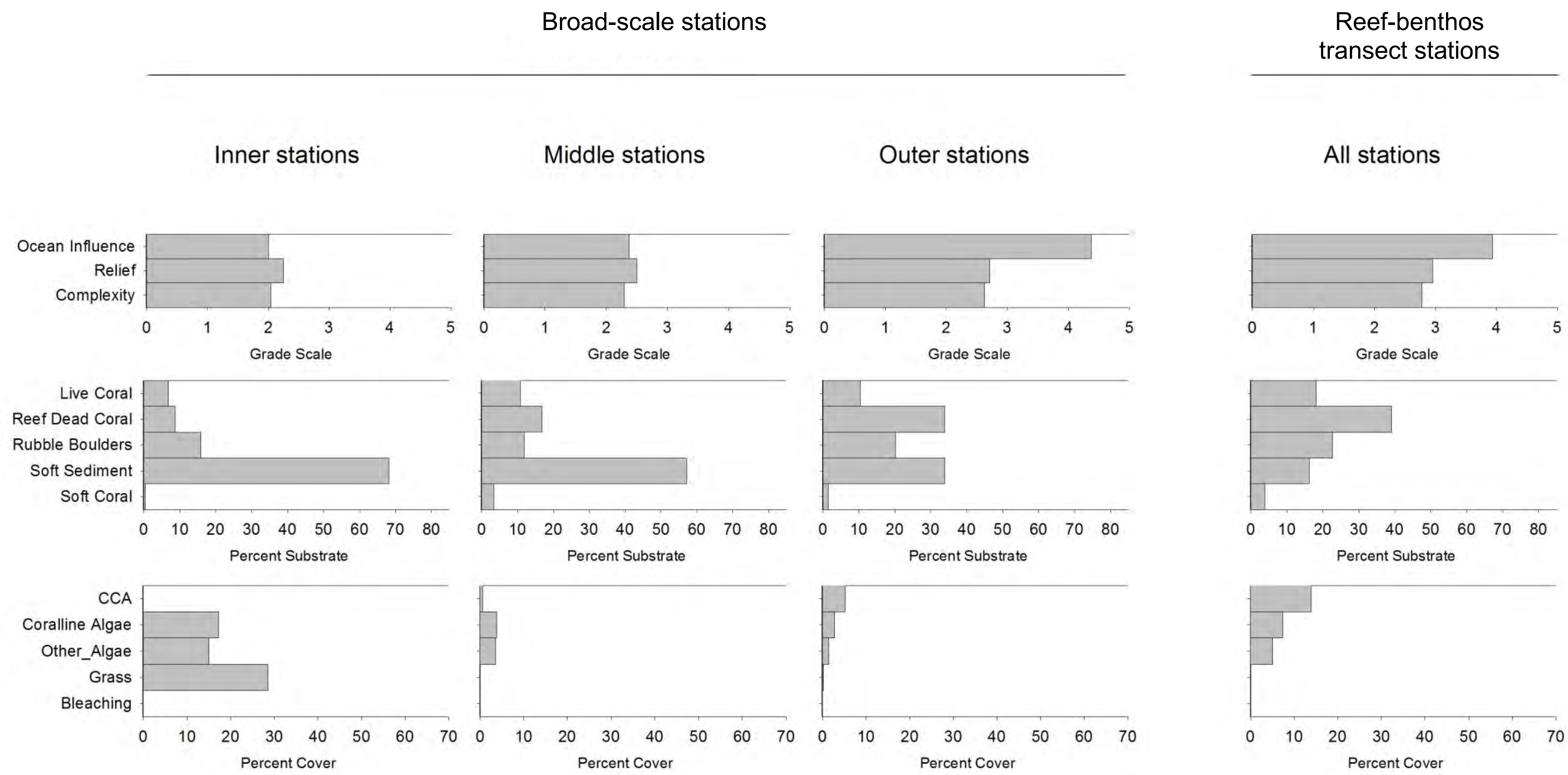
SE = Standard error; n = number.

4.3.10 Rarumana species size review — all survey methods (continued)

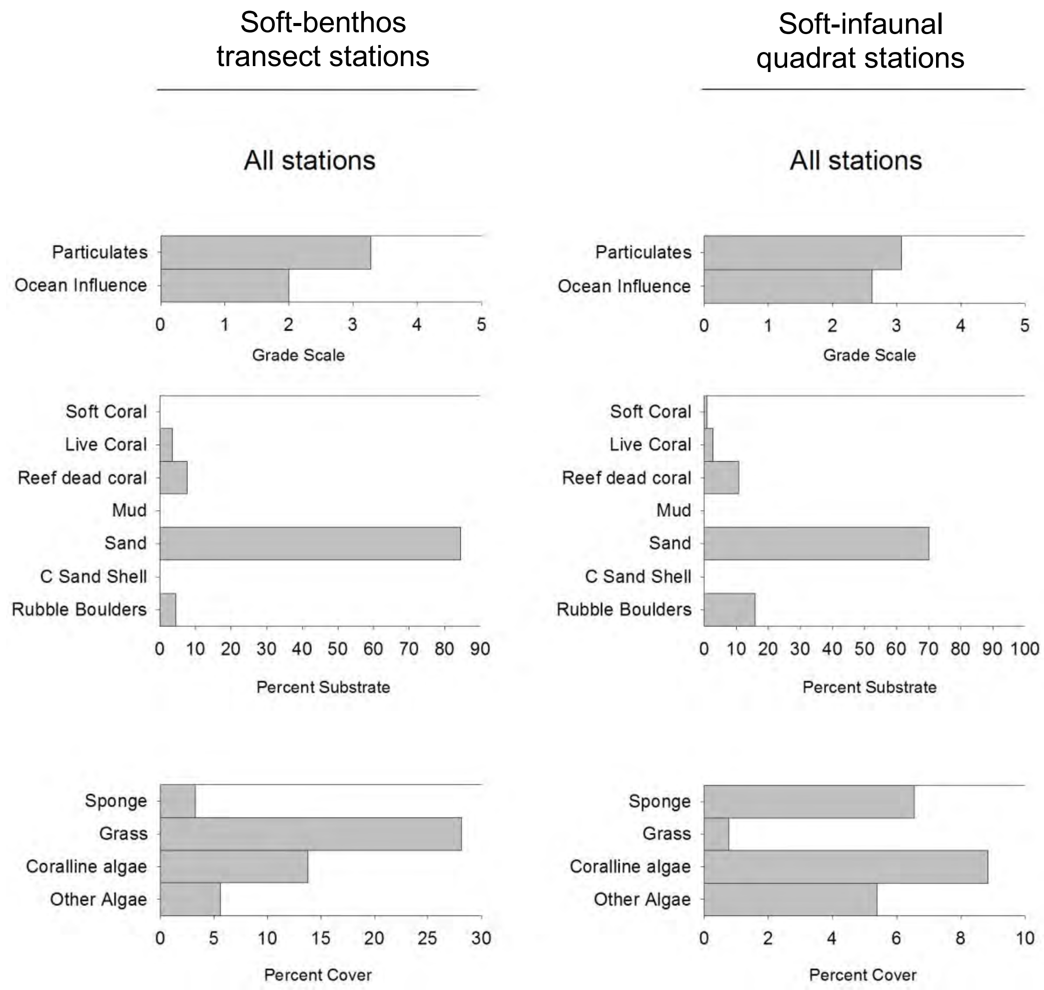
Species	Mean length (cm)	SE	n
Stichodactyla spp.			23
Spondylus spp.			21
Latirolagena smaragdula			17
Fromia spp.			15
Panulirus versicolor			15
Holothuria coluber			13
Turbo argyrostomus			12
Hyotissa spp.			11
Thais spp.			11
Acanthaster planci			11
Pteria spp.			11
Chama spp.			11
Conus distans			10
Cypraea annulus			9
Heterocentrotus mammillatus			9
Linckia guildingi			8
Conus miles			7
Conus marmoreus			7
Lambis millepeda			7
Cerithium aluco			6
Lambis chiragra			5
Actinopyga miliaris			4
Cassiopea spp.			4
Vasum ceramicum			4
Cypraea spp.			4
Drupa rubusidaeus			3
Conus lividus			3
Etisus splendidus			3
Turbo spp.			3
Saron spp.			2
Lambis scorpius			2
Lysiosquillina maculata			2
Cypraea carneola			2
Cerithium spp.			2
Mespilia globulus			2
Stenopus hispidus			2
Turbo petholatus			1
Turbo setosus			1
Atergatis floridus			1
Conus capitaneus			1
Drupa spp.			1
Conus eburneus			1
Tridacna derasa			1
Tridacna spp.			1
Cypraea moneta			1
Strombus gibberulus gibbosus			1
Tutufa rubeta			1
Thor amboinensis			1
Periglypta puerpera			1

SE = Standard error; n = number.

4.3.11 Habitat descriptors for independent assessments – Rarumana



4.3.11 Habitat descriptors for independent assessments – Rarumana (continued)



4.4 Chubikopi invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in Chubikopi

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga echinites*				+
Bêche-de-mer	*Actinopyga lecanora*		+		
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+	+		+
Bêche-de-mer	*Bohadschia* spp.				+
Bêche-de-mer	*Bohadschia vitiensis*	+			+
Bêche-de-mer	*Holothuria atra*	+	+		+
Bêche-de-mer	*Holothuria edulis*		+		+
Bêche-de-mer	*Holothuria fuscogilva*		+		+
Bêche-de-mer	*Holothuria fuscopunctata*	+			+
Bêche-de-mer	*Stichopus chloronotus*	+			
Bêche-de-mer	*Stichopus hermanni*	+			
Bêche-de-mer	*Stichopus horrens*				+
Bêche-de-mer	*Stichopus vastus*	+			+
Bêche-de-mer	*Thelenota ananas*	+	+		+
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Anadara antiquata*		+		
Bivalve	*Anadara scapha*		+		
Bivalve	*Atrina vexillum*	+	+		+
Bivalve	*Beguina semiorbiculata*	+	+		+
Bivalve	*Chama* spp.	+	+		
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Hyotissa* spp.	+	+		
Bivalve	*Periglypta puerpera*		+		
Bivalve	*Periglypta* spp.	+	+		
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Pinna* spp.		+		+
Bivalve	*Pteria* spp.		+		
Bivalve	*Saccostrea* spp.		+		
Bivalve	*Spondylus* spp.		+		+
Bivalve	*Spondylus squamosus*				+
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		+
Cnidarian	*Cassiopea andromeda*		+		
Cnidarian	*Entacmaea quadricolor*		+		
Cnidarian	*Stichodactyla gigantea*	+			
Cnidarian	*Stichodactyla* spp.	+	+		+
Crustacean	*Panulirus versicolor*	+			+
Crustacean	*Portunus* spp.		+		
Crustacean	*Stenopus hispidus*		+		
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cerithium nodulosum*	+	+		
Gastropod	*Chicoreus brunneus*		+		
Gastropod	*Chicoreus* spp.		+		

+ = presence of the species.

4.4.1 Invertebrate species recorded in different assessments in Chubikopi (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Conus distans*		+		+
Gastropod	*Conus ebraeus*		+		
Gastropod	*Conus flavidus*		+		
Gastropod	*Conus leopardus*		+		+
Gastropod	*Conus litteratus*	+	+		
Gastropod	*Conus lividus*		+		+
Gastropod	*Conus marmoreus*	+	+		
Gastropod	*Conus* spp.		+		
Gastropod	*Conus vexillum*				+
Gastropod	*Conus virgo*	+	+		+
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea erosa*		+		
Gastropod	*Cypraea moneta*		+		
Gastropod	*Cypraea* spp.		+		
Gastropod	*Cypraea tigris*	+	+		
Gastropod	*Drupa rubusidaeus*		+		
Gastropod	*Lambis chiragra*		+		
Gastropod	*Lambis lambis*	+	+		+
Gastropod	*Lambis scorpius*				+
Gastropod	*Latirolagena smaragdula*		+		+
Gastropod	*Nassarius* spp.				+
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Strombus gibberulus gibbosus*		+		
Gastropod	*Strombus luhuanus*	+	+		
Gastropod	*Strombus* spp.	+			
Gastropod	*Tectus conus*		+		
Gastropod	*Tectus pyramis*		+		+
Gastropod	*Thais* spp.		+		+
Gastropod	*Trochus maculata*		+		+
Gastropod	*Trochus niloticus*		+		+
Gastropod	*Trochus* spp.		+		
Gastropod	*Turbo argyrostomus*		+		+
Gastropod	*Turbo chrysostomus*		+		+
Gastropod	*Turbo setosus*		+		
Gastropod	*Turbo* spp.		+		
Gastropod	*Vasum ceramicum*		+		+
Star	*Acanthaster planci*	+	+		+
Star	*Choriaster granulatus*	+	+		
Star	*Culcita novaeguineae*	+	+		+
Star	*Culcita* spp.	+	+		
Star	*Fromia* spp.	+	+		
Star	*Linckia guildingi*	+	+		+
Star	*Linckia laevigata*	+	+		+
Star	*linckia* spp.	+			
Urchin	*Diadema* spp.	+	+		
Urchin	*Echinometra mathaei*		+		+
Urchin	*Echinothrix calamaris*		+		
Urchin	*Echinothrix diadema*		+		+
Urchin	*Heterocentrotus mammillatus*				+

+ = presence of the species.

4.4.2 Chubikopi broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Atrina vexillum	0.7	0.4	72	16.7	0.0	3	0.7	0.5	12	4.1	1.3	2
Beguina semiorbiculata	26.5	9.6	72	173.5	41.6	11	26.5	8.8	12	45.4	10.1	7
Bohadschia argus	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Bohadschia graeffei	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Bohadschia vitiensis	4.6	2.1	72	33.3	11.7	10	4.6	2.9	12	11.1	6.3	5
Cerithium nodulosum	0.5	0.3	72	16.4	0.3	2	0.5	0.3	12	2.8	0.0	2
Chama spp.	3.0	1.3	72	36.1	8.0	6	3.0	1.2	12	7.1	1.4	5
Choriaster granulatus	1.2	0.6	72	20.8	4.2	4	1.2	0.9	12	6.9	4.2	2
Conus litteratus	1.2	0.5	72	16.7	0.0	5	1.2	0.5	12	3.5	0.7	4
Conus marmoreus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Conus virgo	1.6	0.7	72	19.4	2.8	6	1.6	0.8	12	4.9	1.3	4
Culcita novaeguineae	12.0	2.8	72	33.3	5.9	26	12.0	2.8	12	13.1	2.8	11
Culcita spp.	0.9	0.6	72	22.2	5.6	3	0.9	0.7	12	5.6	2.8	2
Cypraea tigris	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Diadema spp.	1.9	1.3	72	66.7	0.0	2	1.9	1.2	12	11.1	0.0	2
Fromia spp.	1.2	0.6	72	20.8	4.2	4	1.2	0.7	12	4.6	1.9	3
Hippopus hippopus	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Holothuria atra	8.6	2.5	72	36.2	7.3	17	8.6	3.9	12	11.4	4.8	9
Holothuria fuscopunctata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Hyotissa spp.	0.9	0.6	72	22.2	5.6	3	0.9	0.5	12	3.7	0.9	3
Lambis lambis	1.2	0.5	72	16.7	0.0	5	1.2	0.5	12	3.5	0.7	4
Linckia guildingi	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Linckia laevigata	5.8	1.8	72	34.7	5.6	12	5.8	2.3	12	11.6	3.2	6
Linckia spp.	0.7	0.7	72	50.0		1	0.7	0.7	12	8.3		1
Panulirus versicolor	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Periglypta spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Pinctada margaritifera	3.2	1.2	72	25.9	4.9	9	3.2	1.4	12	7.8	2.2	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.2 Chubikopi broad-scale assessment data review (continued)
Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Stichodactyla gigantea	1.4	0.8	72	25.0	8.3	4	1.4	1.2	12	8.3	5.6	2
Stichodactyla spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichopus chloronotus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichopus hermanni	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichopus vastus	0.9	0.5	72	16.7	0.0	4	0.9	0.5	12	3.7	0.9	3
Strombus luhuanus	240.7	231.5	72	8666.7	8000.0	2	240.7	230.8	12	1444.3	1333.5	2
Strombus spp.	231.5	231.5	72	16,666.7		1	230.8	230.8	12	2770.1		1
Thelenota ananas	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	32.7	7.6	72	78.6	14.6	30	32.7	12.5	12	43.6	15.0	9
Tridacna maxima	0.9	0.5	72	16.7	0.0	4	0.9	0.6	12	5.6	0.0	2
Tridacna squamosa	0.7	0.5	72	25.0	8.3	2	0.7	0.5	12	4.2	1.4	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Chubikopi reef-benthos transect (RBt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	37.5	10.5	120	346.2	35.1	13	37.5	16.5	20	125.0	35.7	6
Actinopyga lecanora	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Anadara antiquata	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Anadara scapha	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Astralium spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Atrina vexillum	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Beguina semiorbiculata	131.3	56.4	120	1750.0	525.4	9	131.3	75.2	20	656.3	253.1	4
Bohadschia argus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Bohadschia graeffei	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Cassiopea andromeda	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Chubikopi reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Cerithium nodulosum	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Chama spp.	60.4	31.2	120	659.1	294.4	11	60.4	47.5	20	172.6	131.0	7
Chicoreus brunneus	72.9	34.8	120	875.0	338.0	10	72.9	41.8	20	291.7	131.1	5
Chicoreus spp.	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Choriaster granulatus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus distans	6.3	3.6	120	250.0	0.0	3	6.3	4.6	20	62.5	20.8	2
Conus ebraeus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus flavidus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus leopardus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus litteratus	6.3	3.6	120	250.0	0.0	3	6.3	4.6	20	62.5	20.8	2
Conus lividus	35.4	14.3	120	531.3	119.9	8	35.4	16.4	20	141.7	36.3	5
Conus marmoreus	54.2	19.9	120	590.9	140.1	11	54.2	30.2	20	270.8	97.0	4
Conus spp.	29.2	17.3	120	875.0	330.7	4	29.2	18.4	20	194.4	73.5	3
Conus virgo	10.4	5.5	120	312.5	62.5	4	10.4	6.7	20	69.4	27.8	3
Culcita novaeguineae	16.7	7.1	120	333.3	52.7	6	16.7	6.3	20	55.6	8.8	6
Culcita spp.	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Cypraea annulus	18.8	13.0	120	562.5	312.5	4	18.8	12.6	20	93.8	52.1	4
Cypraea erosa	14.6	8.0	120	437.5	119.7	4	14.6	12.6	20	145.8	104.2	2
Cypraea moneta	18.8	7.9	120	375.0	55.9	6	18.8	9.3	20	93.8	19.9	4
Cypraea spp.	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Cypraea tigris	31.3	11.3	120	416.7	72.2	9	31.3	15.4	20	125.0	39.5	5
Diadema spp.	133.3	46.2	120	1454.5	291.6	11	133.3	77.2	20	888.9	204.6	3
Drupa rubusidaeus	10.4	10.4	120	1250.0		1	10.4	10.4	20	208.3		1
Echinometra mathaei	466.7	82.4	120	1333.3	167.8	42	466.7	155.1	20	717.9	208.7	13
Echinothrix calamaris	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Echinothrix diadema	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Entacmaea quadricolor	6.3	3.6	120	250.0	0.0	3	6.3	4.6	20	62.5	20.8	2
Fromia spp.	12.5	9.3	120	750.0	250.0	2	12.5	12.5	20	250.0		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Chubikopi reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Hippopus hippopus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Holothuria atra	18.8	9.0	120	450.0	93.5	5	18.8	9.3	20	93.8	19.9	4
Holothuria edulis	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Holothuria fuscogilva	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Hyotissa spp.	4.2	4.2	120	500.0		1	4.2	4.2	20	83.3		1
Lambis chiragra	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Lambis lambis	6.3	3.6	120	250.0	0.0	3	6.3	4.6	20	62.5	20.8	2
Latirolagena smaragdula	43.8	15.3	120	525.0	94.6	10	43.8	19.7	20	145.8	44.0	6
Linckia guildingi	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Linckia laevigata	137.5	25.1	120	500.0	53.3	33	137.5	46.9	20	305.6	72.2	9
Periglypta puerpera	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Periglypta spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pinctada margaritifera	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	4
Pinna spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pleuroploca filamentosa	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pinctada margaritifera	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	4
Pinna spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pleuroploca filamentosa	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Portunus spp.	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Pteria spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Saccostrea spp.	8.3	5.1	120	333.3	83.3	3	8.3	8.3	20	166.7		1
Spondylus spp.	16.7	6.4	120	285.7	35.7	7	16.7	7.0	20	55.6	13.9	6
Stenopus hispidus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Stichodactyla spp.	10.4	4.6	120	250.0	0.0	5	10.4	5.1	20	52.1	10.4	4
Strombus gibberulus gibbosus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Strombus luhuanus	2397.9	1774.5	120	23979.2	17135.2	12	2397.9	2291.9	20	15986.1	14968.8	3
Tectus conus	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Tectus pyramis	143.8	35.5	120	594.8	112.0	29	143.8	67.6	20	287.5	121.2	10

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Chubikopi reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Thais spp.	218.8	76.3	120	1050.0	319.8	25	218.8	103.9	20	336.5	151.7	13
Thelenota ananas	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tridacna crocea	504.2	70.4	120	930.8	104.1	65	504.2	129.2	20	630.2	145.3	16
Tridacna maxima	31.3	9.1	120	312.5	32.6	12	31.3	10.4	20	69.4	15.5	9
Tridacna squamosa	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Trochus maculata	10.4	4.6	120	250.0	0.0	5	10.4	5.1	20	52.1	10.4	4
Trochus niloticus	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	4
Trochus spp.	4.2	4.2	120	500.0		1	4.2	4.2	20	83.3		1
Turbo argyrostomus	8.3	5.1	120	333.3	83.3	3	8.3	6.5	20	83.3	41.7	2
Turbo chrysostomus	18.8	9.9	120	450.0	145.8	5	18.8	14.6	20	125.0	83.3	3
Turbo setosus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Turbo spp.	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Vasum ceramicum	147.9	54.8	120	934.2	290.5	19	147.9	60.0	20	369.8	112.6	8

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.4 Chubikopi reef-front search (RFs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	9.0	3.8	42	53.8	14.3	7	9.0	3.9	7	12.5	4.5	5
Actinopyga mauritiana	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Astralium spp.	1.1	0.8	42	23.5	0.0	2	1.1	0.7	7	3.9	0.0	2
Atrina vexillum	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Beguina semiorbiculata	3.9	2.8	42	82.4	11.8	2	3.9	2.6	7	13.7	2.0	2
Bohadschia argus	1.1	0.8	42	23.5	0.0	2	1.1	0.7	7	3.9	0.0	2
Bohadschia graeffei	4.5	1.7	42	26.9	3.4	7	4.5	2.2	7	7.8	2.8	4
Conus distans	3.9	1.6	42	27.5	3.9	6	3.9	1.7	7	6.9	1.9	4
Conus lividus	1.1	0.8	42	23.5	0.0	2	1.1	1.1	7	7.8		1
Conus vexillum	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Culcita novaeguineae	1.1	0.8	42	23.5	0.0	2	1.1	0.7	7	3.9	0.0	2
Echinometra mathaei	34.7	16.3	42	112.2	46.8	13	34.7	18.1	7	48.6	22.7	5
Echinothrix diadema	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Heterocentrotus mammillatus	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Holothuria atra	1.7	1.2	42	35.3	11.8	2	1.7	1.7	7	11.8		1
Lambis scorpius	1.1	1.1	42	47.1		1	1.1	1.1	7	7.8		1
Latirolagena smaragdula	5.0	3.7	42	105.9	35.3	2	5.0	5.0	7	35.3		1
Linckia guildingi	1.1	0.8	42	23.5	0.0	2	1.1	0.7	7	3.9	0.0	2
Linckia laevigata	4.5	2.2	42	37.6	9.4	5	4.5	3.3	7	10.5	6.5	3
Panulirus versicolor	1.1	1.1	42	47.1		1	1.1	1.1	7	7.8		1
Pinctada margaritifera	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Spondylus spp.	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Stichodactyla spp.	2.2	1.1	42	23.5	0.0	4	2.2	1.2	7	5.2	1.3	3
Tectus pyramis	11.2	2.8	42	33.6	4.1	14	11.2	6.2	7	19.6	8.9	4
Thais spp.	5.6	1.9	42	29.4	3.9	8	5.6	2.2	7	9.8	2.0	4
Thelenota ananas	1.1	0.8	42	23.5	0.0	2	1.1	0.7	7	3.9	0.0	2
Tridacna crocea	9.5	4.0	42	44.4	13.8	9	9.5	4.5	7	16.7	5.6	4
Tridacna maxima	12.3	3.2	42	34.5	5.6	15	12.3	3.9	7	14.4	3.9	6

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.4 Chubikopi reef-front search (RFs) assessment data review (continued)
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Tridacna squamosa	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Trochus maculata	3.9	2.0	42	32.9	9.4	5	3.9	1.9	7	9.2	1.3	3
Turbo argyrostomus	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Turbo chrysostomus	0.6	0.6	42	23.5		1	0.6	0.6	7	3.9		1
Vasum ceramicum	11.2	3.6	42	42.8	8.3	11	11.2	4.5	7	19.6	3.9	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.5 Chubikopi mother-of-pearl transect (MOPt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	26.0	18.4	24	312.5	62.5	2	26.0	26.0	4	104.2		1
Beguina semiorbiculata	41.7	41.7	24	1000.0		1	41.7	41.7	4	166.7		1
Bohadschia argus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Bohadschia graeffei	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Echinothrix diadema	10.4	10.4	24	250.0		1	10.4	10.4	4	41.7		1
Linckia laevigata	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Nassarius spp.	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Panulirus versicolor	15.6	11.4	24	187.5	62.5	2	15.6	10.0	4	31.3	10.4	2
Pinctada margaritifera	88.5	25.5	24	193.2	35.2	11	88.5	45.3	4	118.1	48.6	3
Tectus pyramis	26.0	10.6	24	125.0	0.0	5	26.0	19.7	4	52.1	31.3	2
Tridacna crocea	562.5	144.7	24	900.0	182.7	15	562.5	210.6	4	562.5	210.6	4
Tridacna maxima	26.0	13.0	24	156.3	31.3	4	26.0	13.1	4	34.7	13.9	3
Trochus maculata	10.4	7.2	24	125.0	0.0	2	10.4	10.4	4	41.7		1
Trochus niloticus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.6 Chubikopi sea cucumber night search (Ns) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia spp.	124.4	31.0	12	165.9	30.1	9	124.4	80.0	2	124.4	80.0	2
Stichopus horrens	84.4	32.5	12	144.8	43.1	7	84.4	48.9	2	84.4	48.9	2
Stichopus vastus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.7 Chubikopi sea cucumber day search (Ds) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga echinites	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Bohadschia vitiensis	2.1	1.6	30	32.1	10.7	2	2.1	2.1	5	10.7		1
Conus leopardus	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Conus virgo	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Holothuria atra	1.4	1.0	30	21.4	0.0	2	1.4	0.9	5	3.6	0.0	2
Holothuria edulis	7.9	4.0	30	58.9	13.5	4	7.9	7.0	5	19.6	16.1	2
Holothuria fuscogilva	6.4	2.7	30	32.1	7.3	6	6.4	4.3	5	16.1	5.4	2
Holothuria fuscopunctata	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Lambis lambis	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Panulirus versicolor	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Pinctada margaritifera	3.6	2.1	30	35.7	7.1	3	3.6	2.3	5	8.9	1.8	2
Pinna spp.	1.4	1.4	30	42.8		1	1.4	1.4	5	7.1		1
Spondylus spp.	3.6	3.6	30	107.1		1	3.6	3.6	5	17.8		1
Spondylus squamosus	2.9	1.7	30	28.6	7.1	3	2.9	2.9	5	14.3		1
Thais spp.	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Thelenota ananas	0.7	0.7	30	21.4		1	0.7	0.7	5	3.6		1
Thelenota anax	14.3	5.9	30	61.2	15.8	7	14.3	11.1	5	35.7	21.4	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.8 Chubikopi species size review — all survey methods

Species	Mean length (cm)	SE	n
Strombus luhuanus	4.2	0.1	2191
Tridacna crocea	7.67	0.2	510
Tectus pyramis	5.69	0.1	94
Vasum ceramicum	6.03	0.3	91
Holothuria atra	19.6	1.1	51
Tridacna maxima	16.4	0.8	46
Chama spp.	10	0.6	42
Pinctada margaritifera	12.3	0.4	41
Bohadschia spp.	13	0.8	28
Conus marmoreus	4.76	0.4	27
Bohadschia vitiensis	24.2	1.1	23
Thelenota anax	51.8	1.6	20
Stichopus horrens	20.9	1.2	19
Conus lividus	5	0.4	19
Cypraea tigris	6.68	0.2	16
Spondylus spp.	12	0.8	14
Conus spp.	4.67	0.3	14
Trochus maculata	4.04	0.3	14
Holothuria edulis	21.2	1.3	13
Conus virgo	7.45	0.5	13
Bohadschia graeffei	25.9	1.5	11
Holothuria fuscogilva	30.2	1.8	10
Turbo chrysostomus	2.5	0.5	10
Lambis lambis	12.2	0.9	9
Conus litteratus	7.75	0.5	8
Bohadschia argus	27	1.6	6
Tridacna squamosa	25.3	1.6	6
Hyotissa spp.	8.75	0.8	6
Thelenota ananas	50.8	4.8	5
Stichopus vastus	32.4	3.4	5
Trochus niloticus	9.12	0.7	5
Cerithium nodulosum	7.88	0.3	4
Hippopus hippopus	17.7	5	3
Holothuria fuscopunctata	22.5	2.5	2
Conus leopardus	10.3	0.3	2
Periglypta puerpera	7.75	0.1	2
Trochus spp.	2.75	0.3	2
Atrina vexillum	15	0	5
Actinopyga echinites	35	0	1
Stichopus hermanni	30	0	1
Actinopyga lecanora	21.5	0	1
Actinopyga mauritiana	17	0	1
Lambis chiragra	13	0	1
Pleuroploca filamentosa	10.8	0	1
Anadara antiquata	6	0	1
Turbo setosus	6	0	1
Conus flavidus	4.5	0	1
Strombus spp.			1000

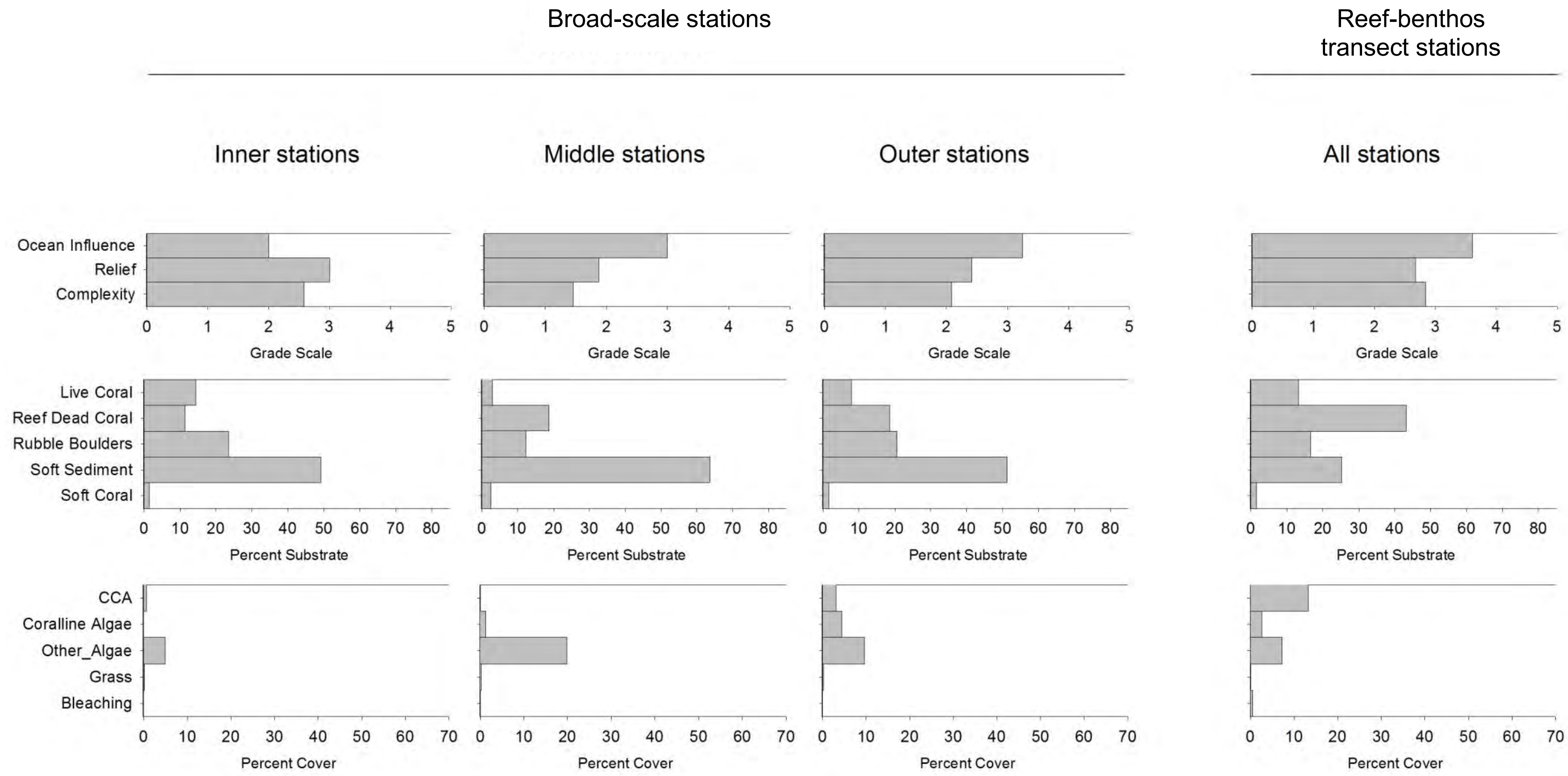
SE = Standard error; n = number.

4.4.8 Chubikopi species size review — all survey methods (continued)

Species	Mean length (cm)	SE	n
Echinometra mathaei			286
Beguina semiorbiculata			193
Thais spp.			116
Linckia laevigata			100
Diadema spp.			72
Culcita novaeguineae			62
Acanthaster planci			40
Chicoreus brunneus			35
Latirolagena smaragdula			30
Fromia spp.			11
Stichodactyla spp.			10
Conus distans			10
Cypraea moneta			9
Cypraea annulus			9
Panulirus versicolor			8
Cypraea erosa			7
Choriaster granulatus			6
Stichodactyla gigantea			6
Culcita spp.			6
Drupa rubusidaeus			5
Turbo argyrostomus			5
Saccostrea spp.			4
Echinothrix diadema			4
Linckia guildingi			4
Spondylus squamosus			4
Entacmaea quadricolor			3
Astralium spp.			3
linckia spp.			3
Pinna spp.			3
Chicoreus spp.			2
Periglypta spp.			2
Lambis scorpius			2
Turbo spp.			2
Portunus spp.			2
Cassiopea andromeda			2
Cypraea spp.			2
Tectus conus			2
Stichopus chloronotus			1
Heterocentrotus mammillatus			1
Stenopus hispidus			1
Strombus gibberulus gibbosus			1
Echinothrix calamaris			1
Pteria spp.			1
Nassarius spp.			1
Conus vexillum			1
Conus ebraeus			1
Anadara scapha			1

SE = Standard error; n = number.

4.4.9 Habitat descriptors for independent assessments – Chubikopi

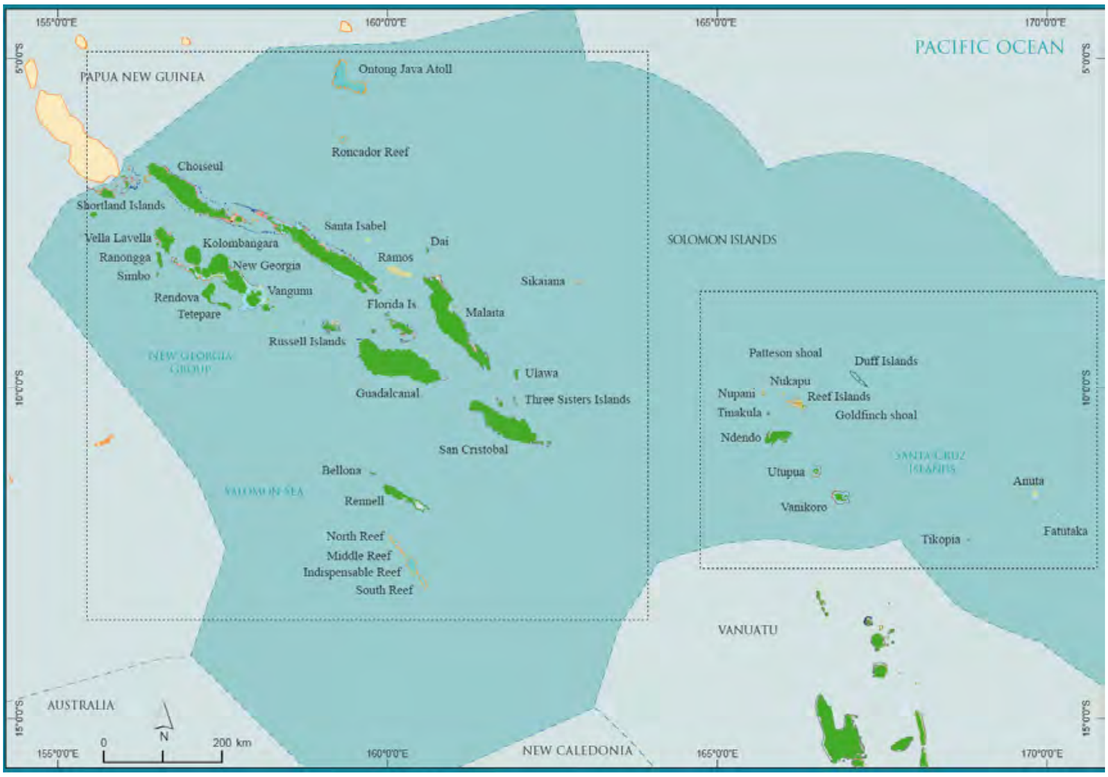


APPENDIX 5: MILLENNIUM CORAL REEF MAPPING PROJECT – SOLOMON ISLANDS

Institut de Recherche pour le Développement, UR 128 (France)
Institute for Marine Remote Sensing, University of South Florida (USA)
National Aeronautics and Space Administration (USA)

Millennium Coral Reef Mapping Project
Solomon Islands

(January 2009)



Map of Solomon Islands

The Institute for Marine Remote Sensing (IMaRS) of University of South Florida (USF) was funded in 2002 by the Oceanography Program of the National Aeronautics and Space Administration (NASA) to characterize, map and estimate the extent of shallow coral reef ecosystems worldwide using high-resolution satellite imagery (Landsat 7 images at 30 meters resolution). Since mid-2003, the project is a partnership between Institut de Recherche Pour le Développement (IRD, France) and USF. The program aims to highlight similarities and differences between reef structures at a scale never considered so far by traditional work based on field studies. It provides a reliable, spatially well constrained data set for biogeochemical budgets, biodiversity assessment, coral reef conservation programs and fisheries. The PROCFish/Coastal project has been using Millennium products in the last four years to optimize sampling strategy, access reliable reef maps, and further help in fishery data interpretation for all targeted countries. PROCFish/C is using Millennium maps only for the fishery grounds surveyed for the project.

For further inquiries regarding the status of the coral reef mapping of Solomon Islands and data availability, please contact:

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Reference: Andréfouët S, *et al.* (2006), Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. Proc 10th Int. Coral Reef Symposium, Okinawa 2004, Japan: pp. 1732–1745.